TRANSACTIONS
OF THE
AMERICAN FISHERIES SOCIETY

DECEMBER, 1914

Published Quarterly by the American Fisheries Society,
Aquarium, New York, N. Y.

Entered at the Post Office at New York, N. Y., as second class matter.

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American Fisheries Society

"To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish."

VOLUME XLIV, NUMBER 1
1914–1915

Edited by The Recording Secretary

DECEMBER, 1914

Published Quarterly by the Society
NEW YORK, N. Y.

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NOTES ON THE NEW KANSAS FISH HATCHERY AND THE FIRST YEAR'S OUTPUT

By Prof. L. L. Dyche,
State Fish and Game Warden, Pratt, Kan.

Since submitting our last report to this society, the contracts for the building of the new Kansas Fish Hatchery have been completed, and much other work has been done to complete details of many parts of the work not included in the contracts. Everything promised by the plans and specifications seems to have been developed and worked out in a satisfactory manner. The new Fish Hatchery is now in working order. The first crop of fish raised in 1913 has been distributed and the second crop raised in 1914 is ready for distribution and is being distributed.

THE EMBANKMENTS SODDED.

All the embankments near the waterline of the ponds are now covered with swamp grass sod. The grass from these sods made a good growth during the spring and summer of 1913. The growth this summer (1914) has been most phenomenal. At the present time the banks near the waterline are densely covered with grass that has made a growth of from three to six feet in height this season. This heavy growth of grass mixed with some semi-aquatic plants completely protects the banks against the action of wind and waves. It also protects the shallow water near the shores where the old fish spawn and the young fish feed. We have never seen a better protection, natural or artificial, for earth embankments of fish ponds.

WATER IN THE NEW PONDS.

All the 99 ponds are full of water and the supply has been good all this year. A few of the ponds in the east

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part of the hatchery suffered some for water during July and August in 1913. However, last year, (1913) was an unusually dry season and the ponds were all new and did not hold water as well as they do this year. It takes some time for artificially scooped out ponds to seal their own bottoms so that they will hold water in good shape. This is especially true of such ponds as those constructed for the State Hatchery where the soil in many places was sandy and the ponds were not puddled.

No fish were lost at the hatchery during the summer and fall of 1913 on account of dry weather and low water. The fish were removed from a few ponds and sorted and placed in other ponds where there was plenty of water. What really bothered the Department was the fact that the water in many of the good streams of the State was so low that we did not think it advisable to place fish in them, and many of the ponds for which fish had been ordered were either dry or the water conditions so bad that we did not think it wise to stock them. This made it necessary to hold fish in the hatchery ponds that would otherwise have been distributed. However, when the water did come in the late fall and spring, the hatchery had the fish to restock the waters of Kansas and, as said in another place, distributed fish in the ponds and streams of 102 of the 105 counties of the State.

PLANT AND ANIMAL LIFE IN THE PONDS.

We have stated before that the new ponds have been stocked with good varieties of water plants. These plants got fairly well started in some ponds last year. This year they have done better and most of the ponds have more or less water plants growing in them. By another year we have reason to believe that all the ponds will have a fairly good supply of suitable water plants.

Fish were placed in the ponds in the spring of 1913. The ponds were new and there was no more food in them than could be found in newly dug cellars, except what was brought in the water through the 21-inch pipe that supplies the hatchery from the Ninnescah River. How-

ever, a considerable amount of food was brought in from this source. The water from the river carried various forms of plant and animal life, and this life, in addition to what was placed in the ponds by artificial processes, soon established itself and furnished more or less food for the newly hatched schools of young fish. We noticed that various forms of insects and their larvae and many forms of small worms, mollusks and crustaceans soon appeared in the waters of the new ponds.

FISH IN THE PONDS.

The ponds were lightly stocked in the spring of 1913 with the common varieties of fish such as bass, crappie, bluegill sunfish, bullhead catfish and goldfish, the latter being put in as a food fish for other fish. These fish, their relation to each other and the manner of stocking the ponds are described in the Bulletins issued by the Department. Owing to the fact that the ponds were new and the supply of food scant, not more than from 1/4 to 1/6 as many brood stock fish were placed in them as were placed in the older ponds where the food supply was established and the spawning grounds well known.

THE OUTPUT OF THE NEW PONDS.

The output of the new ponds was good, all things considered. During the fall of 1913 and the spring of 1914, twenty-nine carloads of fish were distributed. Twenty-five of the twenty-nine carloads of fish, about 300,000, were taken from the new hatchery ponds. These twenty-nine carloads of fish, together with about twenty thousand large tadpoles — the kind that develop into large edible bullfrogs—were distributed in 102 of the 105 counties of the State of Kansas. A carload of fish such as we handle usually ranges from 500 to 14,000, depending upon size, age and weather conditions. We distributed many fish that might be called large for distribution. They would range from six to eighteen inches in length and would weigh from three ounces to three pounds each. We believe in the distribution of good sized

fish,—for reasons see Bulletins published by the Department.

GENERAL OBSERVATIONS.

It was very noticeable that the ponds that had the best supply of vegetable matter were the ones that produced the most and best fish. Ponds that had but little vegetation, and consequently but little food, furnished but few fish. The fish taken from such ponds, if there were many in them, were small, thin and poor. This was especially true of the crappie. The bass taken from such ponds were sometimes unusually large, but as a rule there were not many of them and dissection showed that they were cannibals or were feeding extensively upon other kinds of fish that might be in the ponds. In fact the young black bass in all these ponds were large for their age. Many of them ranged from five to ten inches in length in October, November and December. One bunch measured and weighed November 2, 1913, averaged in length 7½ inches and in weight 6½ ounces. Most of these young bass were taken from ponds that had been stocked with bluegill sunfish and goldfish as food fishes for the bass. The lengths of some of these young bass, in inches, taken just as they came ran thus: 7.6, 7.7, 8.3, 7.8, 7.2, 7.4, 8, 7.3, 7.8, 6.9, 6.8, 7,6 and the corresponding weights were, in ounces: 6.5, 7, 7, 8, 8, 5.5, 6.5, 8.5, 5, 4.5, 4.5, 6.5.

It was very apparent that the ponds that had unfixed and unsettled banks and whose shores were being cut by the waves, produced but few fish. We are more convinced than ever that it is necessary for ponds to have suitable spawning grounds or they will not yield a good supply of fish. What we call suitable spawning grounds for the common kinds of fish such as we raise are described in our Bulletins on fish culture. An unsuitable spawning ground for the large mouthed black bass, for instance, can be found in a pond where the waves cut the banks and where there is little or no vegetation.

Even if fish are hatched under such conditions they seem to disappear soon. To produce such a fish as the large mouthed black bass, it is necessary to have not only the proper spawning grounds but conditions that produce the proper food for both old and young fish. The young fish when first hatched must have certain forms of animal life, and as they grow, other forms must in turn supply the young fish with food; and the time soon comes when the young fish will devour each other, unless young fish of other varieties can be had to fill their ever hungry and expanding stomachs. From young bass less than one and a half inches long we have taken young crappy, young bluegills, young goldfish and young bass. (A preserved specimen of a bass one inch in length that was caught June 2, 1914, while in the act of swallowing a young goldfish 5/8 of an inch in length, was exhibited.)

REMARKS.

Fish culturists are continually receiving letters from people who want to know how to raise fish. Without assuming to give advice to any one, we would like to drop a long distance hint to such people. First we would refer them to bulletins and other literature published by fish culturists; and, second, we would say, that in our judgment, if one desires to know how to raise fish and become a fish culturist, it is almost necessary to make an all day and all night—in fact, an all year and an all life time study of the subject, and especially of the spawning and food habits of the kind or kinds of fish that one desires to produce.

DISCUSSION.

MR. LYDELL, of Michigan: I desire to ask Professor Dyche if the fish introduced into the pond with the bass were blue-gills and sunfish and whether he keeps any small-mouth bass?

Professor Dyche spoke of fish eating one another. We have found that if our old bass are well fed all the time they do not bother the young bass to any great extent. We endeavor to feed our bass in all the ponds once a day and give them all they will eat, and we raise a great many more fingerling bass in the pond with the old bass than we would in a pond from which the old bass were excluded.

PROF. DYCHE: I do not like to put blue-gills in with the bass when

spawning. I put in goldfish, hickory shad, or any sucker-mouthed minnow; but I prefer to spawn blue-gills in an adjoining pond and have a screen between that will allow the young bass to go in where the blue-gills are, or the blue-gills where the bass are. The blue-gills are very bad about eating up the young bass, which are the most foolish of fish when they are little and do not know how to take care of themselves at all. After they have attained some size the tables are turned.

We have no small-mouth bass at all.

As to feeding bass, I plan to raise all I want without feeding them artificially at all. I furnish them with abundant food, just the same, by planning ahead and having certain things grow in the ponds for them to feed on.

MR. WOODS, of Missouri: We do not feed our large bass, but rely on other fish and crayfish. We separate our breeders from the young bass as soon as the latter are able to take care of themselves. Our superintendent, Mr. Cochran, who has had thirty-two years' experience, claims to have the most success by that method.

MR. FEARING, of Rhode Island: For twenty-eight years we have followed the custom of placing the fry in ponds and feeding them. When they are not provided with sufficient food they turn cannibals and the larger ones eat up the smaller. The smaller ones may even attempt to eat the larger. But if they have all the food they want, you can have both large and small trout in the same place and they will leave each other alone.

PROFESSOR DYCHE: The problem of feeding depends on conditions. I have ponds where hornwort, milfoil and other fine-leaved plants, commonly called "moss," grow to such an extent that they form a solid mass. On these plants are found large numbers of molluscs, crustaceans, insects and larvæ, that furnish food for all kinds of fish to start with, and some of those fish make food for the larger fish. I could not seine one of those ponds to get the large fish without destroying all the plants. So they all live there together, and in October or November I can get, when they do well, from 20,000 to 30,000 bass, from four to six inches long, out of an acre pond, and in addition the old fish are still there and in good condition.

Besides, those young fish must feed out of the way of the older ones and fight for existence. Not only that, but they swim all around the pond and learn to know food when they see it; they know the different kinds of insects, the little goldfish, hickory shad and suckers, and learn to feed on them. When you place such fish in a stream they know how to find food. There are many things to be considered in this business of raising fish to stock ponds and streams, and much that we have learned this year may not be of much use next year because the conditions have changed and each pond or stream will have its own peculiarities.

MR. GRAHAM, of Massachusetts: You spoke of losing fish in the tanks by the larger ones devouring the smaller ones. Is that because of underfeeding?

PROFESSOR DYCHE: Yes; I have had a four-pound bass swallow a two-pound bass in a tank while the fish were being moved. I presume it was because they were hungry. Young fish sometimes swallow each other when held in small ponds or tanks a few days before they are shipped.

MR. SPEAKS, of Ohio: In some of our ponds which can be seined readily the young fish are taken as soon as they come from the beds and placed in brooding places. In other cases where seining is difficult, we placed a series of wire fences, to enable the young fish to escape from the old ones. The young fish appear to know instinct-

ively that it is necessary for them to keep entirely away from the old ones. Also by feeding the old ones well their appetites are reduced. We use a great deal of prepared food—meal and meat scraps ground together with some preservative which keeps it indefinitely. By these two methods we have for two years succeeded in raising a very satisfactory number of fish.

In our state fishing has become apparently the prevailing pastime. We estimate that we have now in Ohio nearly a million people who are interested in hook and line fishing. We have succeeded in organizing such persons into clubs for the protection of fish in the streams, until now these clubs are common over the state. But we are put to our wits' ends to supply the demands. Last spring I got eighteen carloads from the marsh districts of Lake Erie. We put out a number of carloads of bass weighing from two to four pounds. We got them very early, so we had the benefit of the spawn in the spring. I have found this so successful that in the future I expect to devote a good deal of effort to restocking by this method. We are fortunate in being able to get from the marsh district an almost unlimited number of small-mouth bass, rock bass and blue-gills. We put out eight carloads of blue-gills in March when the streams would receive the benefit of all the spawn. We are making provisions for enlarging our reservoirs and contemplate adding a number of small systems in various parts of the state. It may be better to follow Professor Dyche's plan of concentrating all effort at one point, but from experience in the past three years with little wild ponds I am convinced that under ordinary conditions such numbers of fry can be raised that it seems unnecessary to go into a big scheme of pond propagation.

In one little pond, with an area of less than half an acre, we put last fall, thirty pairs of breeders. I have seen it several times and looked it over recently. We are just beginning to take out the young and it looks as if there were from 50,000 to 100,000 of them. They have had no careful attention of any kind.

We find, as Professor Dyche does, that the young are cannibals from infancy, but it has been our experience, after five years close observation, that when we feed properly this is greatly reduced.

In Lake Erie waters it is interesting to note the difference in habitat of the two species of bass. In Sandusky Bay one can get a carload of small-mouth bass at one haul of the seine. As soon as the water turns cold they all make for the deepest waters. I have been over the bay during the winter season and have seen tons and tons of pickerel and perch caught through the ice, but never a small-mouth bass, where three months later they could be found at every point. In the marsh district we take carload after carload of large-mouth and never see a small-mouth bass. They do not frequent the same waters, yet we are putting them into every stream in the state. It was a common notion a few years ago that small-mouth bass would not live in our ordinary Ohio streams, but we have disproved this by using them to stock the streams, and this year our fishermen had remarkable success with them.

MR. TITCOMB, of Vermont: I wish to ask Mr. Speaks what he uses for food and where he gets it, and to ask also for Mr. Lydell's experience with prepared foods.

MR. SPEAKS: It is meat ground with meal and some sort of preservative added so that it will keep. It may be had from any of the Chicago packing houses under the name of "prepared fish food." Our fish appear to relish this food and do well with it.

MR. LYDELL, of Michigan: We use beef liver, beef milt and beef scrap. Last year I fed a lot of young perch on this diet and they were four or five inches long by the latter part of August. They

were in a cemented pool and there was nothing else there for them to eat. I tried the same food on bass, but they did not grow satisfactorily on this food exclusively. In the larger ponds where they got a lot of natural food in addition to this, they did very well.

MR. SPEAKS: I wish to inquire as to the experience of the members in placing some carp in bass ponds for food. Last year one of our superintendents stripped two female carp, and in eight days had 400,000 young carp. If food that will suit the bass can be produced in that way it would be a simple matter.

MR. GRAHAM, of Massachusetts: When you once put carp into a pond it is impossible ever to get them out again. If you wish to bring upon your head the condemnation of every fisherman, put the carp in.

MR. SPEAKS: I know from one or two experiences that if bass are introduced into water completely stocked with carp, it will be only a matter of time until the carp disappear. They eat up all the young carp.

PROFESSOR DYCHE: I do not favor carp. They eat up much of the food that the little bass should have and they grow too fast. In the same period a bass will grow to weigh a pound and a carp three pounds. I prefer goldfish for food for bass. Young and small goldfish make excellent food for young bass and larger goldfish are good for the larger bass.

But I do not want you to be misled by what I have said about feeding. I have started out to found a hatchery where I will not have to feed the fish and am working out every idea to make the ponds self-sustaining. I have a great deal of vegetation in the ponds and fish that will consume such matter and convert it into food for other fish. I do not attempt to sort or remove small fish. Twenty thousand of the larger fish eat up eighty thousand smaller ones, and that is all right, as I get rid of the weaker bass that do not grow at a proper rate. I have only 600 bass that I am feeding for a new stock of spawners.

A MEMBER: What is the preservative used in the fish food?

MR. SPEAKS: I do not know. It cannot be injurious because the fish eat it every day and relish it. It is something to prevent the food from becoming rancid.

PRESIDENT WARD: How do they compare in growth with fish fed on other foods?

MR. SPEAKS: We used only this food in one pond last year, and after the pond was frozen over we put lines in and took out bass eight inches long, which is a rather remarkable growth in one season.

THE FEEDING OF TROUT IN RELATION TO THYROID TUMOR

By M. C. MARSH, *State Institute for the Study of Malignant Disease, Buffalo, N. Y.*

The enlargement of the thyroid gland in various members of the salmon family is familiar to most of you either from the fish itself or various publications. This enlargement is of the most various degree and produces often a distinct, palpable swelling, or thyroid tumor. It is a disease process whose various stages have been held to include goiter and cancer, though we now consider the whole process as really one disease. A more detailed account is unnecessary here, extended reports having already been made. Some recent observations make it desirable to offer to this society some brief remarks on the relation of food to this growth.

The tumor occurs in both wild and domesticated trout, but is everywhere rare in the former and very common among the latter in this country. It has been supposed that the raw meat foods so largely fed in American hatcheries were an important factor in causing the tumor growth. These foods, consisting of liver, heart, lungs and other organs of various domestic animals, often mixed with mush made from flour, make a diet to which trout are quite unaccustomed in the wild state but upon which domesticated trout have lived for many generations. However unnatural such foods, trout are able to grow, fatten and reproduce by their use. This feeding of mammalian flesh, however it may predispose to and accentuate the disease in hatcheries, is not necessary to the growth of thyroid tumors. This was inferred from their occasional occurrence in wild fish, especially in a whitefish, which is a species whose natural food is plankton. Now there is important additional proof of this. In the aquarium at Naples, Italy, five among a few hundred sea bass dying in the tanks have developed thyroid tumors. They were fed only upon fresh sea fish,

mostly herring, and were, of course, themselves held in sea water. These tumors were found by Dr. Paul Vonwiller, a Swiss student, working in Naples. Since hitherto no marine fish in sea water has been known to show a thyroid tumor, and since iodine has a marked remedial influence on such growth in fresh water, this find at Naples is of unusual interest. The sea water contains appreciable iodine, in amounts much greater than those effective in fresh water. Yet the tumors originated and progressed in the presence of this iodine content.

In Germany, trout culture is widely and extensively practiced, but there the thyroid tumor is practically unknown. Fish so affected are perhaps as often found in the natural streams as in trout hatcheries. The Germans have, with respect to feeding, a régime quite different from that which obtains here. In the first place sea fish as a food for trout is largely used. Second grade codfish is cheap, and with other members of the cod family has become almost a staple food among the hatcheries. A small quantity of shrimp is added to the fish by some breeders. In the second place it is almost or quite a universal practice to cook the food that is fed to trout, whether it consists itself of fish, or the organs and offal of animals. Sea fish, no doubt fresh water fish also, used as a food, and the cooking of meat used as food, are both practices having at least a tendency to prevent thyroid disease. When both are combined the rarity of thyroid tumor in German hatcheries ceases to cause surprise. There are very few, if any, hatcheries in Germany where artificial propagation of trout is based on raw meat food. One may plausibly infer that these two practices are wholly or chiefly the cause for the freedom of Germany from thyroid tumor, and we may suppose that raw meat-fed fish would there acquire the tumors as they do here and in other countries, although this is not necessarily true. I have recently heard that feeding tests which should determine this question have been begun during the past summer in Germany near Munich.

Through control of the feeding of trout it is likely that practically all of the enlargement of the thyroid gland which is entitled to be considered a disease can be prevented. It is a matter of a properly balanced ration, and exactly what is effective and at the same time cheap enough and procurable in quantity sufficient to meet fish cultural requirements I think no one is yet in a position to say. It is probable that such a food might contain a considerable proportion of meat (liver, heart or lungs, etc.), but that to this should be added a vegetable food (flour), and a smaller portion of fish. With little doubt such a mixture would then be greatly improved by a necessarily small addition of either shrimp, mussels, maggots or insects, or similar animals. In Germany, for instance, one hatchery uses a food consisting of about one-third shrimp and two-thirds fish. Since the fish cost less than a cent and a half per pound and the shrimp about four cents, this is understandable. But in this country shrimp are regarded as a luxury and not usually as an available fish food. However, you will recall that in a paper before the Fourth International Fishery Congress convened in this city in 1908, Mr. Worth set forth the abundance and availability of the fresh water shrimp (*Palaemonetes*) as a fish food and even proposed its culture for this purpose. I imagine that when this resource is properly exploited it will be found that it can be harvested, or cultivated, or both, in quantities adequate for practical use.

Having thus a rather complex mixture of foodstuffs the whole mess should be cooked or at least heated through to the boiling point. I think the basis or starting point of cooking food for trout in Germany was to kill the parasites so largely harbored by the fishes which constitute the food, and which thus add to the danger of the live trout becoming infested. The German Fisheries Research Station constantly advises the hatcheries to cook the food as a general precaution against fish parasites, since the trout have difficulty enough getting away from the direct attacks of parasites without swallowing

them bodily and alive in food. Whether this cooking of the food is further a physiological advantage perhaps does not yet appear.

Now, it has been said that cooking, and the use of fish as food for trout are each to an extent preventives of thyroid tumor. But some recent observations make it seem certain that neither alone is sufficient for this end. One is the occurrence already mentioned, of such tumors, in a small percentage, in the sea bass of the Naples aquarium on a raw fish diet. The other is a practice at a commercial trout farm in Pennsylvania which constitutes a departure in brook trout feeding which should be of much interest to this society aside from any bearing it may have on the present subject. At this hatchery the fry are fed for about two months on beef liver in the usual way. Then a wheat flour mush is added in small and very gradually increasing quantity until by the end of the next four months all the liver is eliminated. After this nothing but cooked flour mush is fed and the trout are so reared to adults. The trout keep in fine condition, resemble wild fish in color and activity and make a surpassing table trout, but they do not grow rapidly. The object of the feeding is to produce a fish resembling the wild trout in edible qualities and without the flavor of liver fed fish. In this success has been achieved and the adults reach a high-priced market. Trout so fed are used as breeders and yield a good quality of eggs which hatch out with excellent results, but it is not claimed that this flour feeding has any advantages from the breeding standpoint. It has been adopted solely to obtain a superior table trout, and this result is achieved at considerable sacrifice of the rate of growth. By universal experience it appears to be demonstrated that rapid growth requires meat or fish feeding.

From other sources, where trials have been made with a purely vegetable food, opinion is for the most part against the practice. Here it is necessary to direct attention to the fact, often demonstrated in fish culture, that the same methods do not work out alike in all hatch-

eries. Feeding which produces certain results under the conditions at one place will produce quite other results at some other place, where the water supply and other component conditions are different. It may also be said, that in introducing or experimenting with vegetable feeding, to break off abruptly the meat feeding of adult trout is to invite failure. It seems necessary to begin with fry and to make the transition very gradual. Whether fry could be made to thrive upon flour alone from the very beginning of feeding has perhaps not been put to the test and the chances seem against it, but surely some one ought to try it.

However well the feeding of flour serves the purpose for which it was undertaken, neither the nature of this food nor its cooking suffice to prevent the development of thyroid tumors. The yearlings and the two and three year olds exhibited growths typical of the disease both to the naked eye and the microscope. The tumors, however, were very small and the percentage of fish affected low, the progress of the disease being much restricted in comparison with liver or other animal tissue feeding. Since the tumors are so closely associated with liver feeding, one might infer that possibly their origin in flour fed fish is to be referred to those first few months of free life, when they received the usual diet of beef liver paste. But the tumor growth is progressive under the flour feeding, and changes of diet which affect the thyroid do so rather quickly. The adult fish with tumors had been without liver or meat food since their first half year of life. Such an inference is opposed to the results of feeding experiments, and can not plausibly be made.

It remains therefore to be proved just what are the constituents of a balanced ration which will be efficient to entirely prevent that relatively immense overgrowth of the thyroid gland which shows as visible tumors, if indeed there be any such combination of foods. Although thus far among the salmonoids, marine fish as a food has not produced any tumors, it has not been so largely fed as other foods, and since sea bass in captivity

under such feeding have developed such tumors, one must be conservative in assuming that fish as food will absolutely protect the trouts. This matter of the balanced ration for trout in fish culture is fundamentally important and rather difficult, as it is in human and animal feeding. It is not more demanded as a preventive of thyroid disease than against fish disease in general, for when the diet is as exactly adapted as possible to the needs of fish, the latter have a better defense against all their diseases and parasites.

Thyroid tumor disease does not impress most trout culturists as a very serious enemy to their operations, and in this they have much justification, for even enormous relative enlargements of the thyroid are yet so small as not to force themselves on the attention. The very large tumors are not common, and it is exceptional when the mortality is high at any stage. The fish culturist does not and need not give himself any particular worry over thyroid disease, though we may assume he would rather not have any of it in his ponds. That a gland should become enlarged to hundreds, perhaps thousands of times its normal size, is, of course, not desirable and indicates something is wrong. One can say in general that the situation can at least be greatly improved by diluting the liver and other mammalian food materials used, with flour and especially with fish, shrimp or any natural food available.

Since a thyroid tumor in a trout is a form of fish cancer, and there has always been some talk of the contagiousness of cancer, it may be well here to insist on making some common sense distinctions. Infectious diseases are those caused by microbes, that is, microorganisms or minute parasites, and most of them may be easily "caught" or passed from person to person. But some of them do not transfer readily from person to person, that is, they are not readily contagious. One can scarcely "catch" them. Now cancer has not even been shown to be an infectious, that is, a parasitic disease. It can only be transferred from one subject to another,

and this with some difficulty, by transplanting a piece of the actual cancer, as illustrated in the lower animals; and it has to be into an animal of the same species. While there is the widest difference of opinion concerning the cause or causes of cancer, nobody at all—not even those who think it caused by a parasite—thinks it is contagious, or "catching," after the fashion of our known infectious diseases. It is proper to say that fish cancer is not contagious. Careful experiments show that they do not catch it from each other even by the closest association. Of course, no one need hesitate to catch, handle, buy, sell or eat fish of any kind on account of cancer. Fish are always eaten cooked. I have eaten trout with thyroid tumors, and the results were exactly like those from eating trout without thyroid tumors. They even taste exactly the same. I would eat the tumors themselves and not without hope of finding a new delicacy, were it not that they are too valuable for other purposes.

DISCUSSION.

MR. TITCOMB, of Vermont: Mr. Marsh has covered the subject so fully that there is not much opportunity for discussion, but I wish to ask one or two questions. Is the food the cause of these tumors, or is it in any way related? In what conditions as to other food, space and water were these fish kept that were fed on flour? Could they get any animal life out of the water?

MR. MARSH: I would not say that the food is the cause of the tumor, it is only the predisposing factor. It enables the real active agent to act more readily and on more fish. The fish were kept in ponds larger than the ordinary ponds used at hatcheries—perhaps half an acre in extent. They were fed no insects, nothing but flour of a low grade, not quite white. It is not whole wheat ground up, but it has a small amount of the hull of the grain.

MR. TITCOMB: Was the flour cooked, and do you think it would be advisable to mix raw flour with liver?

MR. MARSH: The flour is cooked. I asked the fish culturist about mixing the food, but he thought there would be a mechanical difficulty in giving the mixture the proper consistence to feed the fish.

PRESIDENT WARD: It is probable that the raw flour would be absolutely indigestible.

MR. HAYFORD, of New Jersey: The newspapers have given so much publicity to certain scientific articles that our correspondence files show that there has been considerable alarm over the possibility that fish might be cause of human cancer. Consequently it is pleasing to be reassured that there is strong improbability that cancer of human beings can be derived from hatchery-bred trout.

THE USE OF COPPER SULPHATE FOR THE DESTRUCTION OF OBNOXIOUS FISHES IN PONDS AND LAKES

By John W. Titcomb,
State Fish and Game Commissioner for Vermont.

In the early days of the State Fish Commission it was found that black bass multiplied rapidly when introduced into new waters and as a result the Fish Commissioners in the various New England states, and particularly in Vermont, proceeded to introduce black bass in trout ponds and lakes where the trout fishing had become poor. The bass thrived until the trout were all devoured, and then, for lack of sufficient food and range, they were forced to live on each other and in some instances, due to environment, became a stunted race. Perch, pickerel, bullheads and other coarse fishes were introduced either by the Commissioners or by individuals. As a result many cold water ponds and lakes have been ruined for trout and furnish rather poor returns to the angler in the warm water fishes which succeed them.

To illustrate conditions, attention has recently been called to the fact that in one town there are fourteen trout ponds ranging in area from ten to thirty acres, all of which contain perch. The presence of this species renders the waters almost uninhabitable for the trout family, none of which is armed to compete with its spiny rayed enemy.

Fortunately a remedy for these conditions has been discovered which, at comparatively small expense, makes it possible to restore some of the smaller lakes and ponds to their original condition as trout waters.

*The use of copper sulphate for the destruction of algæ in municipal water supplies first led to experiments to ascertain how strong a solution can be used without

*Kellerman, Bul. 76, and Bul. 100, part VII, U. S. Dept. of Agriculture.

destroying fish. Advantage is now being taken of the knowledge thus obtained to see how little copper sulphate can be used to exterminate fish.

The first attempt in Vermont to exterminate the introduced species by the use of copper sulphate was made at Silver Lake in the town of Barnard in October 1913. So far as the writer knows it is the first attempt of its kind anywhere. It would have been more satisfactory to begin with a body of water of less area and shallower, but it happened that the lake was drawn down to an unusually low level this summer, thus reducing its area from about one hundred to sixty-five acres or less and its depth some six or eight feet. At low water level the maximum depth was twenty-five feet. It contained pike, pickerel (*Esox lucius*), pike-perch, yellow perch and horned pouts, all in limited numbers, and afforded rather indifferent fishing.

The copper sulphate was administered by dragging it over the surface in gunny sacks. Two launches and a number of row boats were employed for the purpose. At the first attempt, 2700 pounds of copper sulphate were administered, but this was not sufficient to kill all the fish and at a second attempt 3600 pounds were administered. The copper sulphate precipitates quickly. On each occasion it took about six hours to administer the poison. Dead fish began to rise the evening of the same day. More rose the second day and some on the third day.

It was hoped that all the fish in the pond had been killed, but recent reports indicate that a few pike survived.

This is the beginning of a movement to restore some of the trout waters to their primeval conditions.

With the changes rapidly taking place in the natural conditions of our forest and streams, the trout streams will naturally grow less in number. The ponds and lakes will, if properly conserved, continue to afford recreation and food supply long after many of the streams are dry or are too polluted to permit of fish life. Upon these natural ponds and lakes, then, and upon artificial ponds and

lakes must we look more and more for our supply of native food and game fishes.

The copper sulphate precipitates so rapidly that there is little danger of contaminating streams flowing out of lakes while the poison is being administered.

As a result of the experiment at Silver Lake, the Lake Tarleton Club in New Hampshire has undertaken the extermination of pickerel in a forty acre trout pond with a view of restoring it to its primeval conditions.

Laboratory tests indicate that twelve pounds of copper sulphate evenly distributed to one million gallons of water will cause the death of such common fishes as pike-perch, yellow perch, and pickerel (*Esox reticulatus*). These are the species most commonly found in the trout ponds of New England, but many such waters are ruined for trout by the presence of black bass.

If the water contains an abnormal amount of lime a larger proportion of copper sulphate must be used. As it is impossible to know all of the subaqueous conditions, variations of depth, spring holes in the bottom of the ponds, etc., twenty to thirty pounds of copper sulphate per million gallons is a safer solution to use, as the success of the work depends upon the extermination of every pair of fish of the species it is desired to kill. With present knowledge it is impossible to tell what solution is necessary to exterminate black bass, but it must be much stronger than the one above referred to. No laboratory tests have been made with the pike, pickerel (*Esox lucius*), but from the results at Silver Lake where thirty pounds of copper sulphate were used to 100 million gallons, it is evident that this species is in the class with the black bass. There is no definite information as to the resistant qualities of the rock bass which also infests many waters in the northern states which were once trout waters and which, but for the presence of some of these fishes, would still be trout waters.

To persons undertaking to destroy fish in a pond or lake the following suggestions are offered:

First ascertain the volume of water. This, of course,

necessitates ascertaining the area and average depth. In sounding for depth it would be well to mark with buoys the deepest places. Note, if possible, any spring holes under the surface of the lake and mark them. Note all possible sources of water supply—even the smallest rivulets.

Copper sulphate wholesales at around 5½ cents per pound and comes in barrels. It should be transferred to bran-sacks or some form of bag of loosely woven material. For rowboats, fifty pounds to a sack is sufficient. For power boats, one hundred pounds is a convenient amount to handle.

By the use of a 12-foot joist or bar equally strong fastened crosswise of the stern of the boat, a sack may be fastened at each end so that two bags may be drawn through the water by each boat. The sack should be suspended at the surface of the water with no more of it under water than is necessary to dissolve the contents.

The copper sulphate should be thus distributed along the entire surface of the lake at intervals not exceeding twelve feet apart and the more quickly it is done the better. In other words, the more boats that can be mustered into the service the better, with a view to a general, simultaneous distribution. Each boat should move at about the same pace as that of a fisherman when trolling.

The deeper portions and the spring holes should be covered more thoroughly than the shallower portions. If a definite boiling spring is found in the lake put a small sack of the material over it so that the water will percolate through it.

After the surface of the lake has been covered as thoroughly as possible and as near to the shore as boats can take it, have men on foot drag sacks around the edge of the shore line. Every stream or rivulet must be covered with the material as far up as objectionable fish are known to go. A strong solution of the mixture may be poured into the small streams at intervals with good effect. However, the dissolved copper sulphate precipitates so quickly that there may be conditions in tributary

streams where the introduction of lime would be more far-reaching in its effect than copper sulphate.

To avoid the necessity of having each boatman return to the source of supply one boat should be detailed to carry a supply of sacks filled and ready to replace the empty ones at any place on the lake where needed. This is important.

Some of the copper sulphate will not dissolve readily and the supply boat will find a few pounds remaining in each sack when he makes the exchange. This can be gathered from the various nearly empty sacks into one and this may be dragged over the surface until dissolved. To deposit a bag of the material at any one place will have very little effect. It must be dissolved at the surface of the water in ponds of ordinary depths. There is too little knowledge of the subject to attempt to advise how to exterminate fish in very deep lakes.

DISCUSSION.

PROF. DYCHE, of Kansas: There are unquestionably tremendous opportunities for improving the productiveness of waters by getting rid of surplus fishes and introducing finer species. However, you cannot attempt to destroy a species of fish in a pond for the introduction of others unless you destroy all of them. If more than a single individual of the former species is left it will be only a question of time till conditions are back where they were before. Unless the destruction is complete the introduction of finer species must fail.

MR. GRAHAM, of Massachusetts: In New England and New York there are numerous ponds that formerly contained trout and salmon, which today contain only bass, perch, pickerel and such species. There is a great demand for the planting of trout and salmon in these ponds, but is almost impossible to establish them in the presence of the other fish. This work of Mr. Titcomb's is very important in showing how we may be rid of the pernicious fishes. At the suggestion of Mr. Titcomb I tried out this method on a pond belonging to a friend. The pond was full of pickerel. We first drained it down till there was only the stream running through, and then put in the copper sulphate at the spring which feeds the pond. We kept this up for a week, and at the end of that time it was impossible to find any living thing in that stream except the bullheads—they seemed to thrive on it.

In a little pond in my back yard, about 12 by 30 by 2½ feet deep, in which I have a number of kinds of fish, I desired to get rid of the algæ. I used about a half pound of copper sulphate in a sprinkling can of water and distributed it about over the surface. It was very effective on the algæ, which died and sank to the bottom, but there was a secondary effect produced by the decomposition of the algæ in which there was a large amount of carbon dioxide liberated. The immediate effect of this was that the fishes came to the surface gasping

for air. The suckers came first, then the black bass, and later both died. The perch and sunfish withstood it perfectly, but a number of minnows were lost. The bullheads all came to the surface, but none of them died.

MR. TITCOMB: We must learn in all cases what proportions to use. In one town we have ten trout ponds which, I believe, could be rid of the yellow perch and pike-perch successfully, at a cost of perhaps $400 to $500, and so restore them as trout ponds, together with the streams tributary to them.

MR. BOWER, of Michigan: We have in Michigan thousands of lakes containing undesirable fishes and we would be very glad to find some method of destroying all the desirable as well as the undesirable fishes in order to start in with a clean sweep, using only the best and most desirable species. I wish to inquire whether there is any method of reaching fishes in deep lakes, say down to 100 feet? Also I wish to inquire whether it is feasible to destroy the carp, which bury themselves in the mud? Perhaps the bullheads escape by burying themselves in the mud, and so escape the toxic effects of the copper sulphate.

MR. TITCOMB: In Dr. Kalbfuss's experiments he found that the carp was one of the first to succumb. I think it is even more sensitive than the trout and one can get rid of the trout without destroying the other fishes by making the solution only one part in six millions. That is getting it down to very small proportions and it is not easy to figure the cubic contents of a lake. As to deeper waters, I think it is possible in any depth of water; but I have not tried it at a depth greater than 25 feet.

A MEMBER: How does this affect the fish? If they are stunned or killed outright are they rendered unfit for food?

MR. TITCOMB: They die slowly and come to the surface. They do not keep well after they are killed by this method, and I do not think any one would care to eat them.

MR. MARSH, of New York: I believe Mr. Bower could use copper sulphate in lakes of any depth. It is merely necessary to sink the bag to the depth you wish to reach and let the crystals dissolve there where they will come into contact with the fishes you wish to kill.

MR. COBB, of Minnesota: We had an experience with copper sulphate, but it is not as valuable as it might be, for we do not know just what took place. In a small lake used for bathing purposes all the fish were reported dying. I went out to it and found that all the animal and vegetable life of the pond was dead or dying and discovered a substance on the shore that proved to be copper sulphate. The work was evidently done in the evening by persons having access to boats. One thing which interested me was that horses were drinking from the lake the next morning and campers were getting their drinking water there, and it had apparently no effect on any of them.

MR. TITCOMB: That brings out very clearly the fact that the copper sulphate precipitates very rapidly. You can poison a lake very effectively and feel perfectly sure that you have not destroyed the fishes in a stream below.

A MEMBER: How soon afterwards can a lake be restocked? If it can be done soon it would be possible to clean out some of the desirable fish and hold them for restocking the pond after the others have been exterminated.

MR. TITCOMB: That is quite feasible. After three or four days the fish could be put back safely.

A MEMBER: If the fish were good to eat after being killed in this way it might be a very dangerous thing in the hands of certain people who make a practice of getting fish in any way they can. If they

were to use this method our lakes would soon be depleted of all the fish.

MR. TITCOMB: They could kill the fish readily enough, but I think they would not care to try it, since they would not want to eat fish poisoned in this manner.

SUGGESTIONS AS TO INDICES OF THE SUITABILITY OF BODIES OF WATER FOR FISHES

By Dr. V. E. Shelford,

University of Illinois, Urbana, Ill.

The relations of fishes to environment are very complex due to the great complexity of the environment itself. This complexity seems to grow greater as our knowledge of it is increased and our perspective widened. The decomposition of organic matter in water under the action of bacteria yields many substances, even under primeval conditions, the physiological effects of which have been too little studied to make a statement of their importance practicable at the present time. When we look to the field of contamination and the products which it yields the complexity is increased many fold. Still, in spite of this, we believe that it is practicable to use the presence of certain conditions as indices of the suitability of an entire great complex for food fishes.

In such a discussion we must keep in mind the fact that in fresh water the majority of food fishes deposit their eggs on the bottom. The eggs of many marine fishes rest on the bottom, but a considerable per cent. have pelagic eggs. It is to the bottom that the dead bodies of organisms sink and decompose and, accordingly, at or near the bottom the poisonous products of decomposition occur in greatest quantity. Decomposition of the bodies of plants and animals results finally in gases such as ammonia, carbon dioxide, hydrogen sulfide, methane, etc., which diffuse rather slowly to the surface and into the atmosphere. Thus the extent to which they occur is dependent upon the amount of decomposition and the circulation of the water. It must further be borne in mind that the same processes of decomposition which result in these gases consume oxygen and as a rule there is insufficient oxygen for eggs and young fishes and in many

cases for adult fishes where these decomposition products are present.

Turning to the fishes themselves we note that their presence or absence is controlled by (a), their ability to recognize the presence of strange or deleterious substances and to turn back when they are encountered, and (b), by their survival or death in situations where they cannot escape the deleterious conditions. Their ability to recognize strange or deleterious substances has been shown (Shelford and Allee '11; Shelford and Powers '14; Wells, unpublished) to be very elaborate and effective. Fishes recognize exceedingly minute quantities of numerous substances and not only turn back upon encountering them, but are able to recognize and orient their bodies with reference to increases and decreases of such substances often present in water. Various workers have shown that the products of decomposition are in the main very poisonous to fishes, especially to eggs and young fry (Wells '13 and citations). It must further be noted that all fishes young and adult require oxygen and eggs require a large quantity of it for development. Aside from the ill effects of the decomposition products themselves, there is usually little oxygen in their presence, especially in fresh water. From these considerations it is readily seen that it is useless to expect the presence of food fishes where the bottom of the waters generally contain any quantity of decomposition products. Thus in seeking indices of the suitability of bodies of water for fishes we are concerned primarily with decomposition products. The peculiar physiological constitution of the fishes in question is, of course, a matter for consideration, for the character of different species differs in this respect. However, the difference between different species is one of degree and special habits. The effects of the various decomposition products are the same in a wide range of species with only slight differences in degree. Furthermore when we consider the best food fishes (we believe both fresh water and marine fishes though our experience with the latter has been limited), we find that,

considering their behavior they are very sensitive to decomposition products and their life and death resistance to them is low. The less sensitive fishes are usually of less food value. Food fishes usually live associated with organisms which, like themselves, are very sensitive to decomposition substances, and these organisms are usually absent when the fishes are.

Indices are then of three types (1), results of the inspection of bottom, (2), results of chemical tests of the water for decomposition products, and (3), the presence or absence of index organisms of a semi-stationary character, such as snails, etc. Here we will concern ourselves with the first two types only. The third is doubtless the basis of common though restricted practice in judging the suitability of waters for fishes, being the result of experience of individual naturalists, but is not as yet organized for general purposes. This is to be taken up experimentally by the writer in connection with the work of the Illinois State Laboratory of Natural History to be reported on later.

Considering the first two we must comment separately upon fresh and salt water. If a body of fresh water is to support the most desirable fishes it should have an area of clean sand, gravel or other terrigenous bottom covered by from six inches to two feet of water and an area of emerging and submerged vegetation to supply food. It is probable that for the best results these three areas should be about equal. The terrigenous bottom should usually be free from blackened debris for this usually accompanies decomposition. It should be borne in mind, however, that there is nothing deleterious about humus provided the material in it has passed the early decomposition stages. Thus darkened bottom usually, though not always, indicates decomposition and bad conditions. For many fishes an area of water more than four feet deep is relatively unimportant. This much of the inspection can readily be completed by a cursory mapping of the different areas in the body of water. Since most bodies of water contain sufficient vegetation

to supply insects and other food for more fishes than can exist there, *the amount of terrigenous bottom up to one-third of that occupied by vegetation may be regarded as an index of the suitability of the body of water for food fishes.*

The second index is essential but must accord with the first. The chemical character of the water must be such that the fishes will not suffer from it or leave on account of it. Carbon dioxide results from the decomposition of organic matter. In the process oxygen is consumed so that the presence of any quantity of carbon dioxide nearly always indicates lack of oxygen. Fishes are very sensitive to carbon dioxide, turning back from increase of one or two cubic centimeters per liter of the gas in solution. Their reactions are especially striking when carbon dioxide is accompanied by lack of oxygen (Shelford and Allee '12). Likewise low oxygen and high carbon dioxide in combination are more rapidly fatal than any other combination of these two factors (Wells '13). While exact figures cannot be given it is probable that the carbon dioxide content of water over breeding grounds (terrigenous bottom) should not average more than one cubic centimeter per liter, nor exceed 5 cubic centimeters during the summer months. Such amounts are not usually accompanied by lack of oxygen. *Thus the amount of carbon dioxide may be taken as an index* of the suitability of the water.

In salt water the more complex conditions make additional indices necessary. As in fresh water, bottom conditions are important to fishes which use them for breeding. Clean rock, sand, or gravel bottom in one to six feet of water (at low tide) and free from darkened decomposing matter and foul odor is probably essential to the eggs of many salt water species because of the poisonous character of decomposition products. Thus in general the relative absence of decomposition products from the shallow water of any bay or enclosure may be regarded as favorable to demersal fishes like the herring.

In the sea where such vast areas are connected the be-

havior of fishes plays a most important role (Shelford and Powers '14) as is shown by the well known erratic and commercially important migrations of the herring. These fishes recognize slight deviations from neutrality with a precision not excelled by litmus paper, and turn back very constantly from acidity such as is given in 1 cubic centimeter of carbon dioxide per liter. Essential neutrality is usually selected by herring. Twenty cubic centimeters of carbon dioxide per liter in the presence of oxygen to saturation is more quickly fatal to herring than is the same amount to any number of fresh water species.

Decomposition in the sea nearly always takes place in the presence of certain bacteria which yield quantities of hydrogen sulfide. This is often accompanied by carbon dioxide and lack of oxygen. In shallow shore waters it may exist in the presence of abundant oxygen and essential neutrality because of the use of the carbon dioxide by the plants and their production of oxygen in the process of photosynthesis. Fishes not only turn back on encountering hydrogen sulfide but it is more quickly fatal to them than any other gas of common occurrence. *Thus we must add the amount of hydrogen sulfide as an index of the suitability of sea water.* A good sea water should not contain more than a trace of this gas.

To summarize, we note that *the amount of terrigenous bottom and of free carbon dioxide serve as indices for bodies of fresh water while the amount of clean bottom, carbon dioxide and hydrogen sulfide serve in bays and enclosures of the sea.* The determination of these gases is not difficult provided one has a chemist make the required solutions. Contaminations such as sewage, organic wastes from slaughter houses, etc., influence the water much as does an increase in the natural organic matter and the indices apply where the commonest forms of contamination occur. The writer is familiar with cases in which these requirements have apparently been met and still the body of water proved unsatisfactory for the production of fishes, but in spite of these exceptions

he regards these indices a suitable working basis, in no way preventing the proper investigation of such exceptions as exist.

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PROGRESS IN THE PROPAGATION OF THE DIAMOND-BACK TERRAPIN

By Lewis Radcliffe,

U. S. Bureau of Fisheries, Washington, D. C.

In 1904, Dr. K. Mitsukuri[1] made the following statement:

"The place occupied among gastronomical delicacies by the diamond-back terrapin in America and by the green turtle in England is taken by the 'Suppon,' or the snapping turtle, in Japan. The three are equally esteemed and equally high priced, but the Japanese epicure has this advantage over his brothers of other lands—he has no longer any fear of having the supply of the luscious reptile exhausted. This desirable condition is owing to the successful efforts of a Mr. Hattori, who has spared no pains to bring his turtle farms to a high pitch of perfection and is able to turn out tens of thousands of these reptiles every year."

During the ten years that have elapsed since that statement was made, the Bureau of Fisheries has perfected its experiments on the cultivation of the diamond-back terrapin conducted at Beaufort, N. C., to a point where American culturists may now expect to duplicate the work of Mr. Hattori, and supply the market with thousands of terrapin each year.

Previous attempts of buyers and others unfamiliar with the requirements of terrapin culture, to propagate terrapin have met with little success beyond the hatching of the eggs in beds provided for the purpose. Last year a company was formed at Beaufort, N. C., and plans following closely the methods perfected by the Bureau of Fisheries were adopted for growing terrapin for market on a large scale. This company has built an excellent plant covering several acres and stocked it with about

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[1]In Bulletin of the U. S. Bureau of Fisheries for 1904, vol. xxiv, p. 260.

4500 terrapin, of which 1800 are adult breeding females. The adaptability of terrapin to artificial conditions was well illustrated in this case in that breeders purchased by the company during the laying season of 1913, continued their activities in captivity and from the eggs thus laid over 700 young terrapin were added to the company's stock. This year's brood numbers over 3500 and would have been considerably greater save for some mistakes in the management of the laying beds. The annual brood at the Beaufort Laboratory has shown a marked growth in numbers, beginning with 12 in 1909, there were 460 in 1911 and over 1500 in 1913.

One of the factors that has seemed especially unfavorable to terrapin culture as a commercial proposition has been the long period that it was expected would be required for the terrapin to reach a marketable size. While the experimental results at Beaufort are still incomplete, it now appears that this period may be considerably shortened by improving on nature's methods. You are aware that during the winter months the terrapin hibernate. It is believed that the young terrapin, as a rule, remain in the nest during the first winter and do not begin feeding until the following spring, having increased very little if any in size during this period. At Beaufort the young are not allowed to remain in the nest but are dug out shortly after hatching, placed in wooden tanks, and soon begin to eat. At the approach of cold weather part of them are placed in hibernating boxes and the rest are transferred to the terrapin house, which is modeled after the order of a greenhouse and is heated, the temperature not being allowed to fall below about 75° F. The warmth in this building is sufficient to keep the terrapin active and feeding. The start which they thus acquire enables them to grow more rapidly during the following summer, increasing the lead they had in the spring over stock which was allowed to hibernate.

New-born terrapin average slightly more than one inch in length. This is the length of the flat plastron (bottom shell) measured along the median line and, expressed in

inches, is the standard of length used. The rate of increase in length for terrapin allowed to hibernate each year is about one inch, the growth of the males being slower after the second year. A year-old terrapin of average size that has hibernated the first winter should measure a little over two inches. Of the remaining 500 young terrapin of the brood of 1913 belonging to the Beaufort terrapin company and fed last winter, the largest one now measures four inches, or nearly twice the size of the average terrapin not fed during the first winter, and 200 of this lot will measure three inches and over. The rate of growth of terrapin is exceedingly variable and the experiments with winter feeding are still too incomplete to enable us to determine the time required for the majority of the stock to reach a marketable size, but results of the character mentioned indicate that winter feeding may do much to hasten their growth.

After the first year of confinement, the loss of adults is negligible. As an instance of this, of over 3000 terrapin purchased by the Beaufort company in 1913, only two have died during the active season this year. The loss after hatching, of young terrapin from adult stock held in confinement for several years, is also very small, being about 5% at the Beaufort Laboratory. Aside from the initial cost of pounds and breeders, in places where fresh fish may be purchased cheaply, the running expenses of a terrapin farm should be light. These factors, added to the adaptability of this form to artificial conditions, should make the subject of terrapin culture an interesting undertaking to those of you who are fish culturists and whose sphere of action lies within the natural range of the species. Before undertaking to stock depleted waters, proper laws governing the taking of terrapin should be required and a public sentiment that will insist on their enforcement aroused. Stock grown for distribution should be fed the first winter and planted late in the following summer.

Doubtless many questions relating to the construction of breeding pens, selection of breeding stock, care of

adults, eggs and young, will arise in the minds of those of you who are interested in this subject. These subjects are discussed in Economic Circular No. 5 of the Bureau of Fisheries, issued June 24, 1913. This paper is entitled "Artificial Propagation of the Diamond-Back Terrapin" and was written by W. P. Hay and H. D. Aller, who have been most closely associated with the progress of the experiments at Beaufort.

NOTES ON SOME NORTH CAROLINA SHARKS AND RAYS

By Lewis Radcliffe,

U. S. Bureau of Fisheries, Washington, D. C.

During the course of preparation of a report on the sharks and rays found in the vicinity of Beaufort, N. C., the difficulties of the field man who secures one of these monsters of the sea to determine its identity, have frequently been felt. One cannot carry a 12 to 40-foot shark with ease to his library or workshop, nor does he, as a rule, have his library with him. In the majority of cases I have found that if the jaws and a portion of the skin from below the dorsal fin are saved, these will afford sufficient material for determining the identity of the species. I hope the specimens which will be shown you, and a few notes regarding them, may prove of interest.

As you are aware, the teeth aid the mouth in seizing, holding, cutting or crushing the various kinds of food material. The diversity in form and arrangement of these organs, developed according to the needs of the particular species, is surprising. In the sand shark (*Carcharias taurus*), the teeth are long and subulate, well fitted for seizing and tearing to pieces smaller fishes. It is said that the species is very voracious, that they work together in schools and surround and attack schools of other fish, even those imprisoned in the nets of the fishermen. The teeth of the thresher shark (*Vulpecula marina*) are similar in form. This species is also reported to be very destructive to fish life, using its tail, which is about as long as the rest of the body, to strike and stun, or kill, the unfortunate members of the school of fish who fail to get out of its reach.

In many species of sharks, some or all of the teeth are triangular, with or without serrate cutting edges. This is true for the man-eater (*Carcharodon carcharias*), the blue shark (*Galeus glaucus*), most of the species of the genus *Carcharhinus* and others. In the hammer head

(*Cestracion zygaena*) a transition to the paved type of teeth may be noted. The teeth of the two dogfishes common to our coast are very unlike. In the spiny dogfish (*Squalus acanthias*), they are compressed, with a distinct cutting edge; in the smooth dogfish (*Galeorhinus lævis*), they are blunt, in pavement.

Certain of the rays have powerful crushing jaws which are capable of breaking the thick shells of clams and other mollusks upon which they feed. The paved teeth of the cow-nosed ray (*Rhinoptera quadriloba*) and the spotted sting-ray (*Aetobatus narinari*) are well fitted for this purpose, and the functioning teeth of these are usually very much pitted and worn by such use. The spotted sting-ray, which reaches a length of 12 feet or more, feeds almost entirely on clams, which it digs from the natural beds. The specimen from which the jaws, which I will show you, were taken was 9 feet, 6½ inches long. The stomach of this specimen contained a considerable quantity of the meats of clams without any pieces of the shells. As much as a gallon of clams is stated to have been taken from the stomach of a single individual and no pieces of shell were found. A surprising degree of specialization is revealed to us, as shown by the ability of this species to dig the clams, to crush or open the shells and separate the meat from the shells.

In some of the rays the teeth differ according to sex, those of the female being blunt, while those of the male are sharp pointed, in some cases almost needle-like. We find such differences in the barn-door or smooth skate (*Raja stabuliforis*), in some of the sting-rays, of which *Dasybatus hastatus* is an example, and in the small devil-fish (*Mobula hypostoma*).

A microscopic examination of the armature of the skin of different species of sharks and some of the rays, will disclose as great variation in the form of these defenses as have been found in the teeth. When these calcified papillæ are small and close set, they are referred to as dermal denticles, and the skin is called "shagreen." In some cases they are larger, taking the form of tubercles,

bucklers or spines. As a rule, in the sharks the denticles from a particular body region are very uniform in shape. In many species this form appears to remain constant through life, in others there is some modification with age. Once we have learned the form and the variation, if any, for a given species, these have an important classificatory value.

One of the questions frequently asked regarding the sharks is that of whether they will attack a human being. On this subject we have very little positive information.

As an illustration of their ferocity I wish to relate an incident that happened at Beaufort this summer. On August 8, a small school of large tiger sharks (*Galeocerdo arcticus*) appeared in the Fort Macon channel near the Fisheries Laboratory, swimming around the Fisheries Steamer "Fish Hawk."

A baited shark hook thrown over the side was seized by the largest of the school. The line offered little resistance to this big fellow and he disappeared, taking bait and hook with him. During the time that was required to secure and bait another hook, the rest of the school came up under the stern of the ship, showing no fear for the men a few feet above them. Apparently they were very hungry and prepared to grasp anything in the nature of food that might fall to them. When the second hook was thrown over it was seized by one of these. This shark, which was 8 ⅔ feet in length was killed and brought on deck. For the second time the hook was thrown overboard and soon another specimen, slightly over 10 feet in length, was hanging from the boom with its head out of the water. On the third cast another, 9 feet 2 inches in length, was hooked. At this time a shark, larger than any of those taken, swam up to the one hanging from the boom and, raising his head partially out of the water, seized the dead shark by the throat. As he did so, Captain O'Brien began shooting at him with a 32-caliber revolver, shooting as rapidly as he could take aim. The shots seemed only to infuriate the shark, and he shook the dead one so viciously as to make it doubtful

whether the boom would withstand his onslaught. Finally he tore a very large section out of the unfortunate one's belly, tearing out and devouring the entire liver and leaving a gaping hole across the entire width of the body, large enough to permit a child to crawl into the body cavity. At this instant one of the Captain's bullets hit a vital spot and, after a lively struggle on the part of a launch's crew, a rope was secured around the shark's tail and the four were brought to the laboratory for examination. The last shark was 12 feet in length, and the liver of the smaller one was still in its stomach,—the estimated weight of this was 40 pounds.

DISCUSSION.

MR. FEARING, of Rhode Island: Some years ago when I was going around the world I was requested by Mr. Agassiz to make notes of any absolutely authentic cases of sharks attacking human beings. He believed that there is no shark known at the present time that will attack a living man and there is no shark known whose jaws are capable of biting a man's leg off.

I inquired wherever I went. In Singapore, where the sharks are thicker than in any other place I remember, except in Java in the very warm waters under the equator, I approached the English captain of the water police who had been there for over twenty years. He told me that while he had seen thousands of dead bodies that had been mauled and torn by sharks, he had never known, in all his experience, of a case where a shark had attacked a living person. In Aden I saw a boy, who, it was said, had had his leg bitten off by a shark. On careful inquiry, however, it developed that he was drunk and was run over by an ox cart and injured so that his leg had to be amputated. That was the nearest to any actual case that I was able to discover in a trip around the world! However, Dr. Chas. H. Townsend has told me that he has absolute personal proof and that he has himself seen natives in the tropics grabbed by sharks and eaten.

SOME CASES OF NARROWLY RESTRICTED PARASITISM AMONG COMMERCIAL SPECIES OF FRESH WATER MUSSELS

By Dr. A. D. Howard,

U. S. Bureau of Fisheries, Fairport, Iowa.

The U. S. Bureau of Fisheries has now carried on for some six years an investigation of methods of propagating fresh-water mussels.

The work has gone on beyond the experimental stage and operations have been conducted upon a scale that it is hoped will appreciably increase the supply for commercial purposes.

While certain species of mussels have been successfully dealt with by the methods first adopted, difficulties have been experienced with other species. In a paper read before the American Fisheries Society in 1912 I showed that I had been able to propagate the Warty-back Mussel on the catfish and that apparently they could not be reared on other species. From my studies of natural infection it looked to me at that time as if other cases of restricted parasitism would be found. The subject of natural infection has been made the object of special study at the Fairport Station and some considerable data published showing the species of fish on which the various mussels have been found. The data thus obtained have in some cases pointed conclusively to definite results while in others the interpretation was less obvious.

The identification of the larvæ (*glochidia*) when imbedded in the tissues of the host is uncertain in some forms, and accidental infections of a temporary nature undoubtedly occur. This makes necessary some method of proving out. In practice I have taken the indications obtained from observation of natural infections as a guide and made a test of the suspected species, comparing other species as a control. As the object of the inves-

tigation is to find a method of propagation, such a test meets the ultimate requirements.

The results obtained from these artificial infections are frequently very definite, giving conclusive support to the indications obtained from natural infections.

The following cases are concrete illustrations of this: Last May I undertook a series of experiments to determine to what extent the common fishes could be used in artificial propagation of certain mussels of the family Lampsilinae (Ortmann). The species were the Mucket, *Lampsilis ligamentina* Lam.; the Fat or Lake Mucket, *Lampsilis luteola* Lam., and the Yellow Sand Shell, *Lampsilis anodontoides* Lea.

The glochidia of these species were brought in contact with some sixty fish of 12 different species in each experiment. The infections with each species of mussel were kept separate so that I had three separate experiments. These I carried on under as nearly identical conditions as possible, so that they were practically parallel. The results summarized show what usually occurs in such an experiment. The glochidia took hold more or less on every fish, dropping off of some species in from 1 to 4 days without development, in other remaining on to the full period, which was three weeks in each of these cases. The muckets and fat muckets remained the full period on the basses (*Centrarchidæ*); sea basses (*Serranidæ*), and perches (*Percidæ*). They dropped off of the catfishes (*Siluridæ*), the sheepshead (*Aplodinotus grunniens* Raf.) and the gar (*Lepisosteus platostomus* Raf). The yellow sand shells remained on the gars, and dropped off of all the other species. We have here rather striking results. Chances of error were largely eliminated, from the fact that the experiments were carried parallel. As a further check I have repeated tests where there seemed to be any possibility of doubt.

The mucket and lake mucket are indicated as mussels having an extensive range of parasitism on several genera of fishes, while the yellow sand shell, a closely related

species, is parasitic upon a single genera of fishes far removed genetically from the hosts of the others.

My experiment will illustrate how a study of natural infections was of assistance. The gar would not have been included in this test ordinarily, as it is commonly thrown away as a nuisance. I had found it infected with glochidia which I identified with some uncertainty as *L. anodontoides*. On this account when the opportunity came to infect with the yellow sand shell I made a special effort to bring in the gars with the other fishes.

The natural infections which I collected first on July 17, 1912, were upon the long-nosed gar (*Lepisosteus osseus* Linn.).

The following year infected gills of the alligator gar, (*L. tristoechus* Bl. and Schn.), were sent to the laboratory from Indiana by Mr. Ernest Danglade. These were identified as the glochidia of the yellow sand shell. As I used the short-nosed gar (*L. platostomus*) in my experiments, we have a pretty clear indication that any of the three species of gar is a suitable carrier for this mussel.

Definite results in a similar manner were obtained with the Missouri niggerhead (*Obovaria ellipsis* Lea). Natural infections of doubtful identification had been found on the sturgeon (*Scaphirhynchus platorhynchus* Raf.). This was an especially difficult case because the infections in question were of an appearance and dimensions corresponding to those of a group of glochidia which are much alike, viz.: *Lampsillis ventricosa* Bar., *L. fallaciosa* Simp., *L. higginsii* Lea., *Obovaria ellipsis* Lea., and *Quadrula pustula* Lea. In the experiments the glochidia of *O. ellipsis* remained and passed through the parasitic stage on the sturgeon while they were promptly shed by the black bass, sunfish (*Lepomis pallidus*), sheepshead (*A. grunniens*), white crappie, black crappie, and channel catfish. It will be noted that the sturgeon did not retain glochidia in the other experiments.

The butterfly shell (*Plagiola securis* Lea.) I have found in several instances of natural infection on the sheepshead (*A. grunniens*). In artificial infections I obtained

development upon the sheepshead as expected and immediate shedding by the black bass, the black crappie, and the bluegill sunfish. Mr. Surber (1913)* reported the host as unknown. Two other species of *Plagiola* have been reported on this fish and one of them, *P. donaciformis,* seems to be very common here at Fairport on the sheepshead, so that we apparently have three species of one genus confined chiefly to one host, together with other species of paper shell mussels which are at present considered of little value.

The three fish, the gar, the shovel-nosed sturgeon, and the sheepshead or grunter, which we find to be the carriers of these mussels have held economically quite different positions. The sheepshead and shovel-nose are now esteemed food fishes, although it is not many years ago that the latter was considered worthless. The gar at present is well known, and as I intimated above is considered a nuisance and, worse than that, a positive menace to the welfare of other fishes. The discovery then that it is practically the sole host for one of the most desired of shells is perhaps not agreeable. As a rule, however, we have to take nature as we find her, and for those who expect always to find a *raison d'etre* for each creature, this nursing of the yellow sand shell by the voracious gar will satisfy the belief that things are as they should be.

These results open up interesting problems as to details in the ecological relations of the associated species and the nature of the specific reactions which control them. These are applicable to all cases of specific parasitism and have been solved for some. It is of practical importance to those interested in mussel propagation that at least an answer be found for some of the questions of this nature raised here.

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*Surbur, T., 1913: Notes on the Hosts of Fresh Water Mussels. Bul. Bureau of Fisheries.

A NEW RECORD IN REARING FRESH-WATER PEARL MUSSELS

By Dr. A. D. Howard,
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Last May, Mr. A. F. Shira, of the U. S. Bureau of Fisheries at Lake Peppin, Minnesota, shipped to the Biological Laboratory at Fairport, Iowa, a number of gravid mussels of the species called "fat mucket" *Lampsilis luteola*, Say. This mussel has a reputation for bearing pearls and is of economic importance for its mother-of-pearl used in the manufacture of buttons, etc.

At the time, I was engaged in a series of experiments to determine to what extent the common fishes could be used in artificial propagation of certain members, including this species, of the family Lampsilinæ (Ortmann). On May 21, 1914, I took the glochidia from these mussels and infected a dozen different species of fish; of these, six species proved susceptible and carried the young mussels through their metamorphosis. As the young mussels began to be shed by the fish, I placed a number of infected black bass (*Micropterous salmoides* Lac.) in a floating crate made for the purpose of catching the young mussels as they fell off. The crate I devised to meet a number of difficulties that had been experienced in attempts to raise mussels under observation. In aquaria, either balanced or with running water direct from the usual habitat of the mussels, they do not thrive. The majority are apparently eaten by predacious worms, or those which do not fall prey to their enemies, stop growing, apparently owing to some lack of nutrition.

Among European investigators who have attempted to grow young mussels are M. Brown, W. Harms and Karl Herber.* The latter this year reports having carried the

*Brown, M.: 1889, Die postembryonale Entwicklung der Najaden.
Harms W.: 1909, Postembryonale entwicklungsgeschichte der Unioniden.
Herber, Karl: 1913, Entwicklungsgeschichte von *Anodonta cellensis*, Schröt. Zeitschrift Wiss. Zool., Bd. 108.

juveniles to a size of 3 mm., the largest which has been recorded so far as I know.

Having had about the same indifferent results as other investigators in such attempts, it seemed to me that a promising line of attack for a solution of the problem would be to find some way which would depart from the natural habitat only so far as the necessity of mechanical control demanded. In our situation, where we take the mussels from the Mississippi, the most practicable solution that offered itself to me was a floating crate containing baskets of sufficient size to hold the fish and made of small enough mesh to retain the microscopic mussels.

A crate thus held at the surface accommodates itself to the frequent rise and fall of the river, is convenient of access and removes the young mussel from many of its enemies at the bottom. Another advantage of a surface location is that the precipitation of silt is at a minimum. The crate was constructed from a floating fish car to which were added barrels to give greater buoyancy. Four baskets of rectangular shape were made to fit inside. These consisted of a frame work of galvanized iron attached to a galvanized iron bottom tray. On the frame was stretched copper cloth of one hundred mesh to the inch.

Two or three weeks after obtaining the plant of young mussels from the bass, I found evidence that they were thriving in the crate. A small sample of sediment from the bottom revealed some half dozen or more, and at various intervals during the summer, I readily obtained specimens, making observation on rate of growth and preparing material for anatomical studies. At the last observation in September, the young mussels were about an inch in length (twenty-five millimeters). This compares very favorably with the length of 3 mm. secured by Karl Herber.

For comparison, I put some of the rapidly growing mussels from the crate in an aquarium of running water and compared their growth for a period of three weeks with those growing at the same time in the crate. I

found the rate in the aquarium one-third as fast as in the crate. The rate in the crate was a constantly increasing one, and in the aquarium apparently decreasing. The growth of one inch gives us an actual observation on the growth for one season and removes some uncertainties as to what young mussels may do the first summer.

At this writing, without a study of the records, I am unable to give the percentage of survivals from the original plant, but an estimate of the number gave two hundred living and rapidly growing mussels. All examined had byssi of about six inches length attached to some base in the basket. Each juvenile had the anterior end buried as commonly seen in adult mussels and none were suspended in the current as some have supposed the condition to be with byssiferous forms.

In this experiment we have succeeded in carrying mussels under cultivation, we may say, through what are apparently the most critical periods in the life history, namely, the parasitic and early juvenile stages. Just what bearing these results will have in practical artificial breeding of mussels, is still a question, but the information gained is of obvious value. Early in the investigation of the subject Lefevre and Curtis suggested the feasibility of raising mussels to this more hardy stage and then distributing them. A point in favor of such a method would be that results could be quite definitely measured. By the method of infecting fish and letting them go at large, results are not as readily ascertainable. The planting of mussels according to a definite plan, in favorable locations, might have a distinct advantage over the natural distribution by fish. The assumption of an advantage in the more artificial method would be based upon results with the analagous rearing of fish, young lobsters, oysters, etc. This phase of the subject requires investigation. The raising of young mussels in a floating crate can doubtless be perfected and adapted to many species. I fully realize that the result obtained is only a beginning, but it is at any rate a start.

ON THE SEASONAL DISTRIBUTION OF FISH PARASITES

By Prof. Edwin Linton,

Washington and Jefferson College, Washington, Pa.

This paper is in response to an inquiry addressed to the writer a short time ago. In substance it was desired to know at what particular season one should expect to find worms in the flesh and other parts of various named marine species of food fish.

While satisfied at the outset that there is practically no seasonal periodicity in the occurrence of cases of parasitism among marine fishes, it seems to be worth while to examine some typical cases, of which data are available, in order to set the matter in as clear a light as possible. My own period of investigation on the subject of parasitism has been confined almost exclusively to the months of July and August and parts of the months of June and September. If my data, therefore, were limited to what I have collected myself I would be in a poor position to shed any light on the inquiry. Fortunately I succeeded some years ago in interesting that veteran and intelligent collector, Vinal N. Edwards, of Woods Hole, Mass., in this matter, and, as a result, I have found each season since then a large collection of material waiting for me upon my arrival at Woods Hole for the summer's work. These collections of parasites, mainly from fishes and fish-eating birds, usually requiring from 300 to 400 bottles and vials to accommodate them, have been collected in the months from September to June. As a result of the preliminary study of these collections, I have notes on parasites of many of our common fishes that have been collected throughout the year. In this paper I propose to summarize some of the results obtained from an examination of the collections made by Mr. Edwards and those made by myself in the Woods Hole region from

fishes which are taken there throughout the year or at least during a considerable part of the year.

NEMATODA.

The parasitic helminths that are most commonly encountered belong to the order Nematoda, commonly called round, or thread worms. It may be added that the members of this order come the nearest to the popular conception of the word "worm." In this paper I shall consider only those Nematodes that belong to the family Ascaridæ, which includes the most commonly occurring round worms of fishes. Those who have had much to do with the preparation of fish for the market and have been at all observant can scarcely have escaped noting the not unusual presence of worms of this order enclosed in membranous coverings and distributed on the viscera, sometimes, as is often the case in the whiting, for example, forming a tangled mass on the viscera generally, or, attached to the mesentery. In the butterfish they sometimes occur in considerable numbers on the pyloric cæca. Careful search will reveal the fact that scattering specimens may be found in the mesentery or on the viscera of a large proportion of the food fishes. In most cases they will be found to be coiled in a flat spiral. They are quiescent, although when liberated from the cyst which the tissues of their host have built around them, may become somewhat active. They will measure, as a rule, from 10 to 20 millimeters in length. Whatever the preceding life-history of these worms may have been their situation represents now, as a rule, the final stage of activity in the particular fish in which they are encysted. They are invariably immature and must await the, to them, happy fate of being eaten by a suitable host before they can become sexually mature. This final reproductive stage must be looked for therefore in the alimentary canals of fishes, or of fish-eating animals. Many fishes such as the cod, haddock, pollock, sword-fish, etc., harbor, at the same time, adult nematodes in the alimentary can-

al and immature, encysted forms in the body cavity. Occasionally these worms will be found coiled up in the peritoneal lining of the body cavity, and less often they succeed in penetrating the flesh of their host. For example, in a lot of codfish examined by Mr. Edwards in December, 1908, it was found that in about 2% of them a few of these parasites had penetrated the flesh in the vicinity of the back-bone. A few cases have been brought to my attention where these parasites have been noticed in salt codfish. For example, Dr. C. B. Wilson recently sent me a piece of salt codfish with the request that an examination be made of it. I found in it three immature ascarids, two of which had become lodged in the intermuscular tissue while the third had burrowed into the muscle tissue. Again, this past summer, a fish dealer brought to my laboratory at Woods Hole some ascarids which an agitated customer had returned to him from some salt codfish which had been purchased from him. A more disturbing case is furnished by a correspondent who made the following inquiry:

"Incidentally may I also ask what the worm is which is so commonly met with in the muscles of the cod? In those specimens which are caught in Mahone Bay (on the south shore of Nova Scotia) proper, the worm is almost invariably found, while in the deep water cod, which is gotten some miles outside, it is quite exceptional to meet with the parasite."

In discussing such cases I always attempted to show, what I shall here also attempt to make clear, that the occasional presence of such parasites should not be permitted to arouse alarm. Of course when seen in the process of preparing food for the table it would be no sign of excessive fastidiousness to remove them, any more than it is to reject the occasional caterpillar that the cook may find in the lettuce that has come from the market. Danger or damage to health or digestion is no more to be apprehended in one case than in the other. In short, when it is remembered that such forms will be killed in the cooking, and will then be simply so much

cured meat in the salt cod, it may be easily understood that there can be no such thing as infection following their accidental introduction into the human stomach along with the food. If there should chance to be one who prefers his fresh-fish rare or underdone, I feel reasonably secure, in the absence of experimental proof, that his digestive juices will furnish unkindly cultures for such forms as *Ascaris clavata,* adult in the alimentary canal of the cod, and immature and encysted in the body cavity of a large number of fish.

Upon looking over my records I note immature and encysted nematodes in small numbers in the large sculpin (*Acanthocottus octodecimspinosus*) in all the months in which examinations were made, viz., January, February, March, April, May, July, October, November and December. So far as my records go, therefore, there does not seem to be any seasonal control over the source of infection in this case.

My records for the cod (*Gadus callarius*) are made up, almost entirely from collections made by Mr. Vinal Edwards. They show that examinations were made in January, May, August, October, November and December. Again the record shows adult and young ascarids appearing in each of these months, indicating that there is no particular season when these worms are acquired. When it is recalled that the adult ascarid in the intestine of the cod was an encysted ascarid in the body cavity of another host that was eaten by the cod, where it had lain for months or even years, since one often finds them surrounded by considerable accumulations of degenerate tissue, it can easily be seen that the seasons can have nc effect on the occurrence of such parasites so long as the final and secondary host are associated throughout the year. In cases of migrations, which do not accompany migrations of food, conditions might arise which would occasion a periodicity in the occurrence of parasites.

Whiting (*Merluccius bilinearis*) were examined in the months of March, June, July, August, September, October and November. Immature nematodes were found in

the body cavity of this species in each of these months.

Tomcod (*Microgadus tomcod*) were examined in every month of the year. Adult ascarids were found in each month except July and August, and immature ascarids in each month except June and September. It should be stated that very few tomcod were examined in the months of June, July and September.

Pollock (*Pollachius virens*) were examined in the months of April, May, June, July, September, October and November. Both young and adult ascarids were found in each of these months.

The Hakes (*Phycis tenuis* and *Urophycis chuss*) were examined in the months of May, June, August, September, October and November, and immature ascarids found in each species in each of the months.

Goose-fish (*Lophius piscatorius*) examined in the months of April, May, June, July, August, September, October, November and December yielded immature ascarids in each of these months and adults in all except the months of April and June.

Toad-fish (*Opsanus tau*) examined in May, August, September, October and November yielded both adult and immature ascarids in each month.

ACANTHOCEPHALA.

Similar distribution throughout the year for the Acanthocephala seems to be shown as for the Nematoda. For example, the species *Echinorhynchus acus* was found in the Winter Flounder (*Pseudopleuronectes americanus*) in every month in which examinations were made, viz., January, February, April, May, July, August, September, October, November and December.

TREMATODA.

My record of Trematodes is not so full as that of the other orders of helminths. So far as it reveals anything, however, it gives no indication of seasonal variation. A

distome, recorded under the name *Distomum simplex*, has been found in the tomcod in every month of the year. Another small trematode, *Gasterostomum increscens*, is recorded from the Barracuda (*Sphyræna borealis*) in the months of April, September, October and November.

CESTODA.

A tetrarhynch, *Rhynchobothrium imparispine*, has been found adult in the spiral valve of the winter skate (*Raja ocellata*) in the months of April, May, June, August, September, October and November. The larval stage of this cestode has a wide distribution among the fishes of the Woods Hole region, where it is found encysted, usually on the viscera, and not confined to any season of the year. Another cestode recorded under the name *Dibothrium rugosum*, is of frequent occurrence in the cod, where it is usually found with the heads impacted in the pyloric cæca. It has been collected in the months of January, February, May, August, October, November and December.

I have called attention in previous papers to the exceptional case of flesh parasites afforded by the Butterfish (*Poronotus triacanthus*). For many years, during the months of July and August, I have been examining a greater or lesser number of butterfish for flesh parasites. The parasite is a cestode, *Otobothrium crenacolle*, whose adult stage has been found most frequently in the spiral valve of the Hammerhead Shark, and less frequently in the Dusky and the Sharp-nosed Shark. In addition to the July and August records I have a few also for the months of June and September. On account of the large number of butterfish that have been examined it is worth while to scrutinize the statistics carefully in order to see if there is any indication of an increase in the number of parasitized fish as the season advances. As a matter of simple observation it was obvious in the earlier years in which this flesh parasite was studied

that the proportion of parasitized fish was greater towards the end of the season than it was at the beginning. In some of the succeeding years this difference was not so obvious. Now with data covering additional years available, it will be interesting to see if the conclusion from the observations of former years still holds.

A calculation of the percentage of fish in which no flesh parasites were found, based on examinations made on a considerable number of fish in the months of July and August in the seven years from 1909 to 1914, inclusive, shows a lesser percentage of nonparasitized fish for August than for July, thus indicating a greater degree of parasitism for the month of August in five out of the seven years. This is shown in the following table:

Year	Number of fish examined		Number of fish having no cysts in flesh		Percentage of non-parasitized fish	
	July	August	July	August	July	August
1909	149	49	14	6	0.094	0.122
1910	262	50	72	12	0.274	0.240
1911	58	342	23	63	0.396	0.184
1912	576	171	212	84	0.368	0.491
1913	354	660	163	166	0.460	0.291
1914	235	395	116	184	0.493	0.465
	2134	2565	600	515	0.281	0.200

The result of this calculation, which is based on a sufficiently large number of fish presumably to overcome the effect of the very considerable fluctuation in the degree of parasitism indicated from year to year, seems to be in accord with conclusions reached from observations on each year's record. Furthermore something in the nature of seasonal variation appears to be indicated.

The results of examinations of butterfish for flesh parasites by Mr. Vinal N. Edwards are of interest and are here recorded:

1907	June 7	6	No record of cysts in the flesh.
	Sept. 24	6	"Worms in flesh of each."
1908	June 30	1	No record of cysts in flesh.
	Oct. 10	15	"Flesh full of parasites."
1909	Nov. 13	6	"Many cysts in flesh."
1910	May 31	12	"Cysts in flesh of 9."
1911	May 22	12	"No worms."
	June 17	8	"No worms."
	Sept. 29	100	"Cysts in flesh of all."
	Oct. 3	100	"All contained cysts in flesh."

So far as this record of Mr. Edwards's goes, it shows a decided increase in the proportion of parasitized fish in the latter part of the year. It must be remarked, however, that conclusions should not be drawn from occasional examinations, even if considerable numbers of fish are examined. This may be illustrated by a single case compared with others of its class. It was noted in the earlier years of observation of the flesh parasites of the butterfish that the smaller fish, 100 millimeters or less in length, seldom had parasites in the flesh. This continues to be the rule. Thus, in 1912 out of 220 fish, measuring less than 100 millimeters in length, that were examined for flesh parasites, only 3 were found with cysts in the flesh, and but few in either case. In 1914, out of 76 small fish examined but one was found with cysts in the flesh, and in that case very few. In September, 1911, however, I examined 270 small butterfish, under 100 millimeters in length, 12 on the 9th, 36 on the 11th, and 223 on the 15th, with the following wholly unexpected and exceptional result: Cysts were found in each of the 270, distributed as follows: 23 with very few cysts, 36 with few, 78 with many, 66 with numerous, and 67 with very numerous cysts in the flesh. In this case it is evident that a school of small fish had been exposed to a common source of infection at the same time. I think that there can be no doubt that, as a rule, the butterfish that are taken in the autumn, or late summer, in the waters of the Woods Hole region show a larger percentage that have cysts in the flesh than is the case earlier in the season. I have interpreted this as indicative of a general northward movement of the butterfish from the warmer

waters of the coast farther south. At Beaufort, N. C., I found this species of cestode which is represented by the flesh parasite of the butterfish, the encysted stage, very abundant in the submucosa of many species of fish, and the adult in two species of shark other than the hammerhead, which has thus far proved to be its most usual final host. There is much reason for thinking, therefore, that the chances of infection are many times greater in the latitude of Beaufort than they are off the New England coast. The method of infection, especially where many cysts occur in the flesh, may be easily inferred, when it is remembered that the ripe, egg-containing joints of the adult worm, living in the intestine of a shark, continue active for a long time in sea water, and when discharged in the water along with the fæces of their host, would be greedily eaten by small fish. A single ripe joint may contain many hundreds or even thousands of eggs. Each of these eggs, when once it is swallowed by a fish, may ultimately become an encysted larva. Thus in the extreme case of parasitism of the small fish examined in September, 1911, noted above, it is probable that the school to which they belonged, happened to be in the near vicinity of a shark, most likely a hammerhead, at the time when a considerable number of ripe joints were discharged into the water. The frequent possibility of such happenings will be understood when it is recalled that the chyle in the spiral valve of sharks is often literally swarming with the free joints of these small tapeworms, each of them being the bearer of a large number of eggs.

CONCLUSION.

There does not appear to be evidence of any marked periodicity in the occurrence of helminth parasites of marine fishes, either adult in the alimentary canal, or immature encysted in the tissues of their hosts, beyond what may be expected where fishes are exposed to varying sources of infection in the course of their migrations.

FISH MEAL AS A FOOD FOR TROUT

By Prof. G. C. Embody,

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The College of Agriculture of Cornell University, for the past three years, has offered a Course in Aquiculture. A part of the work of those students electing this course consisted in hatching a certain number of trout eggs, rearing the resulting fry to fingerlings and planting the same in local waters.

Among the many problems which arose was the one concerning fish food. It very early became evident that the classic food, ground liver, could not be used satisfactorily. First, no refrigeration facilities were available, making it necessary to buy only a small amount daily and at a very high price. Second, the daily preparation of this food consumed more of the student's time than was deemed expedient.

A food was desired which might be prepared beforehand in large quantities and which might be kept for a month or so. To this end, a few carp were cleaned and passed through a meat grinder. The resulting hash was boiled tender, passed through a fine sieve, some table salt added and finally one percent boric acid was incorporated in the mixture to insure preservation. The whole was sealed in small wide-mouthed bottles under sterile conditions. It was found that this food would keep for about three weeks. Young rainbow trout were very fond of it and grew satisfactorily. It was not long, however, before the task of preparing the food and removing daily the unconsumed waste from each trough, became so great that a substitute was sought.

In the Transactions of this Society for 1911 (p. 183), Mr. J. J. Stranahan gave an account of his success in feeding bluegill sunfish upon a "Prepared Fish Food," supposed by him to have been made from fresh meat scraps. Upon reading this article, the use of some such dried and concentrated food for salmonoids was sug-

gested to the writer. Accordingly, samples of dried blood, fish meal and various grades of meat scraps were obtained. Up to the present time only the first two have been tried. All attempts to feed young rainbow trout with the blood failed, so this was abandoned after a trial of two weeks. On the other hand, the use of fish meal was so successful that it has been continued for the last two years.

Fish meal, as nearly as can be learned, is that residue obtained after the extraction of oil from fish carcasses. It varies considerably in texture and purity apparently depending upon the place of manufacture. That which was used by the writer was clean, dry, buff in color and consisted of a mixture of fine meal and coarser material, a few particles of which were as large as small peas. By sifting through a screen thirty meshes to the inch, a fine meal was obtained suitable for advanced fry. Passing the residue through a screen with larger meshes, a coarser material fit for fingerlings was obtained; while the last residue was of good size for yearlings.

All sizes of this food have been used successfully both in a dry condition and softened in water. For advanced fry and small fingerlings the writer has merely sprinkled the dry meal over the water surface. The young trout rise and clean it up in a surprisingly short time. A very small portion of the food will sink, but this is immediately seized by the less ambitious feeders. For larger trout the food is first softened by placing for a period of ten or fifteen minutes in sufficient water to cover it. The water is completely absorbed, thereby preventing the extraction of nutritive materials. It is then only necessary to cast a handful at a time over the pond.

Rainbow and brown trout of all sizes will take the food greedily. No trial has been made with brook trout or other salmonoids. All minnows worked with, including the horned dace and various shiners, immediately seized the food without any coaxing. Success was attained also in feeding yellow perch and common sunfish, although it

was found necessary first to introduce live minnows to assist in teaching the former to take the food.

In order to obtain some definite idea of the effect of this meal upon growth, one hundred rainbow trout just beginning to feed were isolated May 26, 1914, in a hatching trough eight feet long by fourteen inches wide. They were fed four times per day for the first two weeks, twice daily for the next four weeks, and from then until September 26, once a day. The mean daily temperature of the water during this period of four months varied from 53° to 61° F.

Total weight of 100=283 gms., or 9½ oz.
Weight of average individual=2.83 gms.
Length of largest fish =3 inches
" smallest fish =1⅝ "
" average fish =2.4 "

CONCLUSION.

Fish meal is a highly concentrated food containing about 65% protein as compared to the 40 or 60% present in the better grades of meat scrap. It consists not only of the flesh but of the bones and scales of fishes, and, therefore, possesses much of the mineral matter needed by the living fish. It lacks the oil which has very little value in the nutrition of fishes.

It is a dry food and, therefore, must be fed in smaller portions than is the case with liver. Because of this dry condition and high protein content, one pound of the meal is equivalent to at least two pounds of liver in nutritive value. And yet the cost is only about three and one-half cents per pound in hundred-pound sacks.

Taking into consideration all of these facts, together with the keeping qualities and the ease of preparation and feeding, it seems to the writer that by its use a great saving in the expense and labor of operating any trout hatchery is possible. Some disadvantages may arise by continued use, but such are not apparent to the writer

at the present time. It is his belief that the product is worthy of a fair trial by every fish culturist.

Author's Note, Dec. 5, 1914: It has been recently ascertained that the "fish meal" referred to above was made from lean beef and not from fish flesh. This error is regretted very much, and in justice to himself the writer desires to say that the food was labelled "fish meal" by the company selling same and was sent to him in answer to a specific request for a product made from fish flesh.

The general results given above are not affected by this mistake. But the portion of the paper referring to the manufacture and composition of the food applies to a meal made from fish flesh. The methods of manufacture and analyses of several brands of true fish meal may be learned from the following publication, namely, "The fish-scrap fertilizer industry of the Atlantc Coast," by J. W. Turrentine, Bulletin No. 2, Bureau of Soils, United States Department of Agriculture.

A meal made from the flesh of salt water fishes may be obtained from The Flavell Company, Asbury Park, N. J.—G. C. EMBODY.

DISCUSSION.

MR. LYDELL, of Michigan: I wish to ask where this food may be obtained and what is the name of it?

PROF. EMBODY: It has been used by poultry men for a good many years. I procured the best meal from Darling & Co., Union Stock Yards, Chicago. It is known by two names, "fish meal" and "fish food."

MR. TITCOMB: I had some of this stuff several years ago. It contained about a pound of sand to five pounds of the so-called meal. This looked to me more like ground meat scraps than fish. We used it successfully with young perch, but with other fish it was a failure.

PROF. EMBODY: The Darlington Co. claims that this is ground fish, and it is very clean. It is probably made from salt water fish, as most of our fish scrap and fertilizer material comes from the Atlantic coast.

THE FISHERIES OF THE PACIFIC COAST

By John N. Cobb,

Editor of the Pacific Fisherman, Seattle, Wash.

But few persons except those intimately associated with the fisheries of the Pacific coast appreciate their magnitude. While the products prepared in other parts of the country circulate widely in their own region, occasionally having a country-wide distribution (as in the case of sardines), certain products of the Pacific coast have a much wider distribution. Canned salmon, almost all of which is packed on this coast, is one of the world's great staples, and the same may be said of salted salmon, while the mild-cured and frozen salmon of the Pacific can be found in all parts of the world except the more remote portions where cold storage is not available. Of the enormous quantity of fresh and frozen halibut consumed in this country, more than nine-tenths come from the Pacific banks, and this product is rapidly making for itself a market in European countries. The most extensive cod banks in the world are to be found off our Alaskan coast, and some day they will support even greater fleets than do the Atlantic banks. At present our Pacific cod find not only a general market in the country west of the Mississippi river, but large quantities are shipped to New England and other points in the East, to the West Indies, Australia, Hawaii, and various Asiatic ports.

Herring are to be found on this coast in immense numbers, while countless other species, some of which are well known to the country at large, as smelt, sea basses, albicore, flounders, sole, tomcod, whitefish, shad and striped bass (both introduced from the Atlantic), are to be found here in large numbers, while others which are peculiar to this coast, as eulachon, black cod, Atka mackerel, etc., are to be found here in great abundance.

Shrimp, crabs, clams, mussels, and scallops are abundant, while both the eastern and the native oyster thrive

well and with more modern methods of cultivation will ultimately prove a very profitable industry. Heretofore it has been a rare occurrence for the transplanted eastern oyster to breed on this coast, but in August last Prof. Trevor Kincaid, of the University of Washington, who has been engaged in making an investigation of the oyster fisheries of the state of Washington for the U. S. Bureau of Fisheries, discovered in Willapa Harbor four generations which have grown and thrived from the spat of the eastern oyster. The importance of this discovery will be patent when I state that heretofore our growers have had to import eastern oysters in the seed and depend upon their growth alone for their profit. A plant for the canning of mussels was established on the northern California coast last spring, and is one of the first in the country to be put to this use.

An idea of the vastness of the Pacific fishing industry may be gained when I state that the census report of 1908 (the last government report containing full data of the fisheries of the United States) places the Pacific coast division, exclusive of Alaska, second only to the Atlantic coast division in almost every particular so far as persons employed and the various items of investment are concerned, while in the matter of quantity of products prepared the Pacific coast division leads all the others, although second to the Atlantic coast division in the total value of products as they leave the hands of the fishermen. Had the fisheries of Alaska been included in the investigation the Pacific coast fisheries would have led all sections in everything except, possibly, in value of products prepared.

The little table below shows the value of the principal fishery products prepared on this cost, exclusive of Canada, during the calendar year 1913. With the exception of halibut, products sold fresh or in the shell are not included, and the best estimate I have been enabled to obtain of these indicates a value of about $2,500,000, making the gross value of all the fishery products prepared on this coast in 1913, over $41,000,000. During

1913 the lower grades of canned salmon sold at figures but slightly above the cost of packing same. This year (1914), however, all grades have been advanced in price from 10 to 40 per cent., and this increase, provided approximately the same pack is made as in 1913, will mean an increased return to the packers of about $7,500,000.

VALUE OF PRINCIPAL PREPARED FISHERY PRODUCTS OF THE PACIFIC COAST IN 1913.

Salmon, canned, salted, mild-cured and frozen,	$33,296,787
Halibut, frozen, fletched and fresh	2,750,000
Fertilizer and Oil from Whales	700,000
Fertilizer and Oil from Fish	250,000
Tuna, canned (77,500 full 48-lb. cases)	500,000
Cod, dry-salted, pickled, etc	375,000
Sardines, canned (73,686 cases 1-lb. ovals)	350,000
Herring, pickled, dry-salted, frozen, etc	200,000
Clams, canned (69,040 full cases)	200,000
Various canned (Trout, 820 cases; shad and shad roe, 5,852 cases, etc.)	125,000
Total	$38,746,787

Since 1908 there has been a great expansion of the industry on this coast, and as but a tithe of our vast production is consumed locally, it has been necessary for our producers to expand their markets throughout the world sufficiently to take care of this production at a remunerative price.

Most of my readers have doubtless during the past year frequently had their attention called to the energetic campaign which is being waged to induce our people to eat more fish. This campaign had its origin in the Northwestern section of this country, and is being systematically pursued not only through the Pacific Fisherman, the only journal representing the fisheries of this coast, but in many other ways. One of the most ef-

fective agents was Economic Circular No. 11, issued by the U. S. Bureau of Fisheries, through the broad-mindedness of Commissioner Smith, and entitled "Canned Salmon: Cheaper than Meats, and Why. Including Fifty Tested Recipes." This little pamphlet has been circulated throughout the world by the Government and is now being translated into various languages by steamship and trading companies which operate to and in foreign countries, and it has proved the greatest "boost" ever given to a food product by this or any other government. Dr. M. E. Pennington, chief Food Research Laboratory, Bureau of Chemistry, Department of Agriculture, has also materially aided the good work by preparing a bulletin entitled "Supplementing Our Meat Supply with Fish," which was published in the 1913 Year Book of the Department.

The fixing of an annual Salmon Day (occurring this year on March 13), on which date all are asked to eat salmon, has also aided in focusing the minds of our people upon the wholesomeness and cheapness of this excellent Pacific product. The Salmon Canners Associations of this coast have also issued a number of booklets, leaflets, etc., telling of the nutritious qualities, food value, etc., of canned salmon, while the tuna, sardine and clam packers have also done a great deal of work along these lines.

This systematic work has been found to yield valuable results to the producers of this coast, and I believe other sections would achieve like results if they were to take up the good work so far as their own special products are concerned. The increasing scarcity of meat, with the consequent high cost of same, is making our work easier each day.

THE PACIFIC FISHERIES SOCIETY

By John N. Cobb, *Secretary, Seattle, Wash.*

The members of this Society will doubtless be interested in learning the details of the formation of a sister society with a much more restricted sphere, viz., The Pacific Fisheries Society.

On March 11, 1914, a meeting of those interested in the upbuilding and perpetuating of the great fisheries of the Pacific slope was held in Seattle, Wash., and it was decided to form a temporary organization and to hold a meeting later in the year for the purpose of making the organization a permanent one. The constitution of this Society, with the exception of a few slight changes necessitated by the present smallness of the membership, was adopted.

The following officers were elected to serve temporarily: President, Carl Westerfeld, California Fish and Game Commission, San Francisco, Cal.; Vice-President, Henry O'Malley, Pacific Coast Superintendent of Hatcheries for U. S. Bureau of Fisheries, Seattle, Wash.; Vice-President, Prof. Trevor Kincaid, Head of the Department of Zoology, University of Washington, Seattle, Wash.; Secretary, John N. Cobb, Editor of the Pacific Fisherman, Seattle, Wash., and Treasurer, Russell Palmer, Seattle, Wash.

The first annual meeting was held at the University of Washington, in Seattle, on June 10-12, 1914, and was attended by over 50 of the 126 members on the rolls of the Society on June 10. A number of interesting and instructive papers were read by the members, not the least important of which was one by Dr. H. M. Smith, U. S. Commissioner of Fisheries, who came to the coast especially to attend this meeting, and who was unanimously elected an honorary member.

The Society voted to retain for another year the officers elected at the March meeting, and in addition the following, to serve as an executive committee: Dr. Barton W. Evermann, Director of the Museum of the California Academy of Sciences, San Francisco, Cal.; C.

McLean Fraser, Director of the Biological Laboratory, Nanaimo, British Columbia; Dr. Charles F. Holder, Pasadena, California; Leslie H. Darwin, Washington Fish and Game Commissioner, Seattle, Wash.; M. J. Kinney, Oregon Fish and Game Commission, Portland, Oregon; Ward T. Bower, Pacific Coast Agent U. S. Bureau of Fisheries, Seattle, Wash., and M. D. Baldwin, Montana Fish and Game Commission, Kalispell, Montana.

It was also decided to hold the next annual meeting in San Francisco in 1915, the date to be fixed later.

The geographical boundaries of the Society are restricted to the states of Washington, Oregon, California, Arizona, Nevada, Idaho and Montana, and the territories of Alaska and Hawaii, in the United States, and the Province of British Columbia in Canada.

CATCH BASIN PONDS

By W. O. Buck,

U. S. Bureau of Fisheries, Neosho, Mo.

The Neosho, Mo., station of the Bureau of Fisheries was planned to provide a water surface of about five acres supplied from a spring yielding about 350 gallons per minute and with a temperature of 57° F. at all seasons. The water was brought to a distributing tank on the highest part of the station grounds and thence to the hatchery and in four other directions to supply several series of ponds and pools and with provision for overflow of surplus to another series of ponds. As this surplus, though varying in amount, is likely to be small, it is supplemented by overflow from four small pools supplied direct from the tank. Overflow from the hatchery furnishes the supply for still another series of ponds and four of these series finally empty into a large pond at the lowest point of the original grounds. All the ponds and pools are arranged so that the overflow is of surface water, the result being that in summer the temperature rises from pond to pond while in winter the reverse is true. Ice seldom forms in the upper ponds and is not often more than three inches thick in the lowest and only for a short time, while in summer an extreme water temperature of 92 has been noted.

Omitting now the questions of evaporation and seepage, although both are important factors of the problem here, it remains to consider the results of the arrangement and to determine the proper use to be made of the different ponds. The sorts of fish to be handled number a dozen or more, the principal ones being rainbow trout, large-mouth and small-mouth black bass, rock bass, crappie and bream.

Rainbow trout spawn here from the latter part of November to early April, bass mostly in May and rock bass and sunfish from April till September, so that the work naturally divides itself into two periods, in winter with

trout and in summer with bass. Trout are handled by the usual method being allowed as much room as practicable in summer and confined in winter where they can be conveniently handled for egg-taking. It will be recognized that in summer they must be held in ponds or pools near the supply tank and that a good flow must be provided to keep the temperature down. This can be accomplished by giving the trout the smaller upper ponds and, by selecting those from which part or all of the overflow can be diverted from the bass ponds below, it is practicable to avoid sending too much water into the latter. Before the station was built the spring had its outlet by a small stream running diagonally across the present grounds and deep enough so that all the ponds may be drained into it and most of them cannot be entirely emptied except into this stream. While this outlet must be used for part or all of the overflow from the trout ponds, with the other sorts it is necessary to keep it tightly closed while the fish are small enough to pass the screens or they will do so and be lost to the station. It may be thought that the overflow from the trout ponds can hardly be too great for the supply of the bass ponds, but it is to be considered that for bass the supply of cold water may easily be too great, not only because they require a rather high temperature but because the small life, on which they feed, is also greatly stimulated by warmth. But besides this it has been found that the young fish are much more easily held in the ponds when the overflow is shut off or nearly so. It is well known that the young fish move about the pond when so small as to be able to pass through almost any screen that can be maintained and that at this stage their tendency is to go down stream. When they are larger and seek the intake, a larger flow may be furnished as the weather is then warmer and there is less likelihood of the water being made too cool.

It is evident, therefore, that some provision must be made to turn part at least of the overflow from the trout ponds away from the lower ponds of their series and for-

tunately this can be done by locating the trout in ponds having a drainage outlet other than to the ponds below. The arrangement is such, however, that it is necessary to supply part of the trout ponds through the hatchery or through other trout ponds or pools. No harm appears to result from this except the risk of communicating disease, but this risk is now an important matter and an effort is being made to effect such a rearrangement that each trout pond shall have its own supply, or better still that each shall have two independent supplies. This latter is now possible since the flow of another and larger spring has been brought to the station.

It is worth considering whether repeated use of water has any causal relation to the appearance of the disease, which has for years been on the increase in hatcheries and the control of which is now a problem of prime importance. But, however this may prove, it is reasonable to avoid risk of infection so far as practicable and for this reason the series or catch-basin plan seems undesirable for trout ponds.

It is also objectionable because aeration is less in the lower ponds unless there is sufficient difference of level to admit of a drop through the air from pond to pond, which is not the case here in most of the series. The other sorts of fish do not appear liable to infection nor to miss the fresh aeration and, the disadvantages not applying, it remains to consider what advantages the catch-basin system offers in their case. Two have been referred to above: (1) economy of water and (2) raising of temperature, the latter being an advantage not only directly to the fish but indirectly by promoting the increase of the minute life necessary for their food. The catch-basin system offers the means of saving and disseminating this. Not that the diffusion from pond to pond is likely to be great at most times, but because it is practicable, when the ponds are drawn, to float it down in great quantity to the pond below. This requires beginning with the lowest pond and working up the series.

Although the pond fish are more adaptable than trout,

it is still worth while to give each sort its proper location. Thus it appears that small-mouth bass do better in rather cool water and crappie are supposed to prefer theirs roily, while sunfish thrive in the warmest locations, and the catch-basin plan affords opportunity to humor these preferences.

It is probably quite impracticable to prevent occasional overflow in some direction in case of heavy rain and on such occasions small fish are likely to pass the screens to the pond below or even through the entire series and into the stream. The chance of this last may be lessened by holding the large lower pond at such a level that it will not easily overflow and the size of the pond makes it unlikely that small fish will promptly find their way around it and out. It is, therefore, to be expected that this pond will collect some fish, which escape from the ponds above and it seems worth while to stock it with a sort as little voracious as available. With this in mind crappie have been bred there for the last few years and have yielded a crop of young although black bass and sunfish have drifted in. It may be of interest to mention that under the plan described above trout are constantly fed and that aquatic plants appear dangerous rather than useful in the trout ponds while the other sorts are never fed and thrive about in proportion as vegetation is made to thrive.

By way of summary attention is invited to four results of the catch-basin arrangement.

1. Economy of water.
2. Control of temperature.
3. Collection of stray fish.
4. Conservation of minute life.

AN EXPERIMENT IN FEEDING YOUNG LARGE MOUTH BASS

By E. N. Carter,

U. S. Bureau of Fisheries, Bullochville, Ga.

The result of an experiment in providing natural food for young large-mouth black bass at the Cold Spring, Ga., station of the U. S. Bureau of Fisheries, may be of interest to the members of this society.

Dr. Hugh M. Smith, in his very interesting book on goldfish culture as practiced in Japan, tells of the methods carried on there of manuring ponds for the purpose of providing the minute life upon which daphnia, etc., thrive. "The essential point," says Dr. Smith, "is the fertilization of the pond, so that the growth of the minute animals and plants that serve as the immediate and ultimate food of the crustaceans may be greatly stimulated."

One of the methods, and the only feasible one at this station, is the spreading of fresh horse manure over the bottom of the rearing pond at the rate of about 100 bushels to the acre. This is left exposed to the sun for about a week before the filling of the pond with water. Dr. Smith writes: "In a few days the color of the water becomes decidedly green from the presence of unicellular algae in great abundance, and in 2 to 4 weeks the water fleas exist in such numbers that they will support many thousand young goldfish with constantly increasing appetites."

Having decided to give this plan a trial with young bass, commencing May 19th, the writer had fresh horse manure spread over the bottom of one of the rearing ponds, Pond D, 32/100 of an acre in area. The manure was spread near the outlet and in the deepest portion of the pond. Each day thereafter, for four days, all manure available at the station stable was spread in the same manner over the balance of the pond. On the seventh

day after the first lot was spread the water in the pond was raised sufficiently to cover this lot and on each succeeding day it was raised until the pond was full and the last lot of manure covered.

By June 10th, 3,000 young bass from an inch to an inch and a quarter long, which had been collected from other rearing ponds, were placed in this pond. From it, up to August 31st, 2,800 fingerlings from 2 to 2½ inches long had been secured for distribution and during September about 100 more 3 inches in length were collected. All of these fish made excellent growth and were in fine condition when shipped. They were given no other food.

This experiment is considered eminently satisfactory and will be repeated next year.

In pond G, 45/100 of an acre in area, and which is supplied largely from small, bottom springs, 7,000 bass from an inch and a quarter to an inch and a half in length were placed, within a day or two of the introduction of fish into Pond D. Pond G had not been previously manured but the natural food it contained was supplemented to some extent by occasional feedings of a ground animal food purchased in Chicago and which is used at this station for feeding young and old fish. From this pond only 750 fingerlings were secured but they were from 3 to 4 inches in length and, of course, fat and in excellent condition. They had attained this condition by feeding on the other 6,250.

Mention of the Chicago food has been made. Repeated experiments at this station have proved that this is not a satisfactory food for bass under 2½ to 3 inches in length, although they take it fairly well after that size has been reached. Even at this 3-inch size, however, they much prefer finely chopped mullet.

THE PADDLE-FISH

(*Polyodon spathula*).

(COMMONLY CALLED "SPOONBILL CAT.")

BY M. L. ALEXANDER,

Pres. State Conservation Commission, New Orleans, La.

This is one of the most singular and interesting fish occurring in American waters. Its range is said to be along the Mississippi Valley from Texas and Louisiana on the south to Minnesota and Wisconsin on the north. It is not uncommon in the Ohio and its larger tributaries, and in the Missouri basin it is found as far west at least as western South Dakota. Its home is mostly in the bayous and lowland streams.

In Louisiana these fish have been rather plentiful in the past, but in recent years, through lack of protective measures, are fast disappearing. They are found in the fresh water lakes of the State and on its rivers and bayous. They sometimes reach an immense size. One of these fishes, a female, was recently taken from a small lake near Angola, Louisiana, which weighed, when dressed, 102 pounds, and contained 10 pounds of eggs. These eggs were sold at $2.00 per pound for manufacturing into caviar, bringing a total of $20. The flesh was disposed of at 10 cents a pound, or for $10.20, bringing, therefore, to the fisherman a gross amount of $30.20.

Another fish of this species was taken from Lake Larto in the northern part of the State, weighing approximately 140 pounds and bringing something over $40.

The spoonbill roe is converted into caviar by the same methods used with sturgeon eggs; that is the fish is opened, the eggs taken out and rubbed through wire screens having a mesh slightly over an eighth of an inch, thereby separating the eggs and removing them from the egg sacs and other foreign substances. Sufficient salt is then added and mixed thoroughly through the eggs, after which they are placed on fine screens to drain. Then they

are packed into cans with a capacity of 50 to 75 pounds and shipped to the markets of the north, principally to New York.

Fishing for this species is carried on in widely different sections of Louisiana, but our principal investigations have been made in White Lake, a body of water 22 miles long and 18 miles across, situated in the southwestern part of the State. The spoonbill cat fisheries of White Lake are probably at present the most important in the State, if not in the south. At one time during December and January, 1913-14, there were ten large outfits operating in this body of water for taking this species exclusively. I am told that four of these outfits netted their owner each over $4000 during the season of three to four months. Practically all of this money was paid them for eggs from which to make caviar. It is said that all but three of the ten companies operating in White Lake averaged a net income of from $2000 to $4000 each; also that the other three made a comfortable living for their owner.

Each outfit consists of two good gasoline boats of not less than fifteen to twenty horse power each, and one good, well-equipped seine of 600 feet in length. The crew of each outfit generally consists of from four to six men.

The method of operating seines in those waters has only been in vogue about a year and is very unique. Its efficiency was discovered quite by accident by some fishermen who were towing a seine across a small lake connected with White Lake and, upon drawing it up, found that a number of the spoonbill had become entangled in its meshes.

Once on the fishing grounds each end of the seine is fastened to a gasoline boat and is then dragged up and down the lake by them all day without being hauled out. About every half hour a fisherman in a row boat starts at one end of the seine and pulls his boat along by the twine which he raises sufficiently to remove each fish as he comes to it, being able to detect the fish by its mild struggles to release itself. As a fish feels the touch of

the seine being dragged along, he shoots up toward the top of the waters so close to the twine that its bill is pushed through one of the meshes where it remains practically motionless until hauled up by the fisherman. We know of the existence of no other species of fish which are sufficiently docile to submit to this mode of capture. To be sure, the paddle or bill conspires to make its capture in this manner easy, but if they possessed one-half the activity of almost any other species of fish they could not be taken in this manner, since their bill is so smooth that it does not become entangled in the coarse twine of which the seines are made. In spite of being so very inactive, these fish cling tenaciously to life, and live a long time out of water, probably fully as long as a catfish under similar conditions. It is hardly necessary to say that the seines, fished in this manner, rarely ever capture any other species of fish, although catfish and the various species of game fish are fairly numerous in White Lake and are readily taken in seines when hauled out upon the surrounding shores or up under a "round-up."

The spoonbill cat taken from White Lake average much smaller than those taken from other bodies of water in that vicinity. The fish taken from this lake are also more uniform in size and much lighter in color than those taken from other waters of the State, even than those taken from smaller lakes connected with White Lake.

We estimate the average weight of the fish taken from White Lake to be from eight to ten pounds each, and each female having eggs suitable for caviar will produce from one to one and a half pounds of roe,—it being only on rare occasions that one is caught which contains over two pounds.

In the investigation by our Fisheries Department in the study of spoonbill cat conditions in White Lake, about the middle of February of this year, it was found that very few females had already deposited their eggs. However, no fully matured milt was found in any of the males captured. The roe from the fish found in this lake is only suitable for caviar from about November 15th or

December 1st until about March 15th or 30th, according to climatic conditions.

In spite of the short season, it is admitted by fishermen who are familiar with the present spoonbill cat conditions in White Lake, as compared with a few years ago, that they are fast disappearing from this lake and other waters of the State. The situation appeared so grave that our Commission had introduced in the State Legislature a bill, which was passed, making a close season on these fish from January 1st to July 15th of each year. Not that it is likely that spawning spoonbill cat will be found in any Louisiana waters as late as July 15th, but this is necessary to prevent the capture and sale of both catfish and spoonbill cat during the close season on catfish.

In spawning season the spoonbill are seen in schools on the borders of the lake close to the hard sandy bottoms. But little is known of the food of this fish; they are bottom feeders and their chief food is probably minute vegetable and animal organisms, found by stirring the mud and vegetation with their spatulate snout.

Previous to last year large quantities of both species were caught, dressed and sold as spoonbill during the catfish close season, the flesh and appearance of both being very similar when dressed and the heads removed.

It is more apparent that such valuable fish as the spoonbill or the sturgeon should never be caught solely for the purpose of selling their flesh at from four to ten cents a pound and that these fish should be protected for the great value of the eggs which they produce.

The fishermen in Louisiana are now being paid from $1.50 to $2.00 per pound for the spoonbill cat roe. We estimate that the value of this industry to the fishermen of the State at the present time, would aggregate approximately $200,000 per annum.

We believe that every effort should be put forth, both by state and federal governments, to propagate these fish and to build up this industry which promises to be one of unlimited magnitude. The State of Louisiana is now, and will continue, giving it its closest attention.

DISCUSSION.

MR. TITCOMB, of Vermont: May I inquire if you have been successful in propagating the spoonbill?

MR. ALEXANDER: We have not made any attempt at propagating this fish so far.

PROF. DYCHE, of Kansas: I should like to know if you have succeeded in obtaining the eggs of the spoonbill? If you have, you have found something entirely new to science.

MR. ALEXANDER: I am inclined to think you can locate the eggs of the spoonbill in the waters to which I have called attention. We have frequent reports of the small fish, measuring an inch or two up. In the shallow waters of the lakes, and in the spawning season, these fishes are seen in large schools around the borders of the lakes, which would indicate that they are there for the purpose of depositing their eggs.

PRESIDENT WARD: There is only one case recorded in the literature of anyone having had what is known to be a ripe female of this species. Are you sure that these females are really ripe and ready to discharge the eggs?

MR. ALEXANDER: There is no question about that in the latter part of February. Mr. E. A. Tulian, the head of our Fisheries Department, told me that they had stripped a number of them. I do not know to what extent scientific men have carried on their search for these eggs, but I am inclined to think they have been making their investigations in the wrong territory. I know of none made in our waters. We will be glad to place every means within our power at their disposal if they will come to us.*

The eggs of the spoonbill are manufactured into caviar, probably sold as Russian caviar. We buy our own eggs back again in this form.

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* On account of the importance of this discovery the Editor took occasion to write to Mr. Alexander after the presentation of his paper, for further data in regard to the eggs of this fish. Mr. Alexander writes in part, "It is possible that only a limited number of eggs could be secured and fertilized, owing to the apparent scarcity of ripe males during the spawning season at White Lake. Our investigations there covered only a few days during the latter part of February, the last few of March and the first few of April, 1914. The operations conducted by us at this point show that a very small portion of the total number of females caught during February contained ripe eggs. Most of these taken during the latter part of March and the first few days of April had either partly or entirely deposited their eggs. However, two or three females contained eggs which were not fully matured. Only two or three nearly ripe males and no spent ones were taken during our February operations, while we found only spent males the last of March. Up to the present time, so far as we know, no ripe eggs of the paddlefish have been found in any of the fish taken from the rivers of our State to which they are indigenous, although the young, not over five or six inches in length, are often seen in the Little, Tensas, Ouachita and Black Rivers early in the spring, so we are told. It is probable that these are hatched in Catahoula Lake. Our experiments with this species were conducted by the head of our Fisheries Department, Mr. E. A. Tulian.

In view of these and other facts I feel confident that I have made no claims that we cannot substantiate."

Zoologists will await further information on this matter with interest.

EDITOR.

We are laying down our opportunities and rights by neglecting to take advantage of our resources and making something out of these fish. I went before the legislature and had them pass a closed season of over six months against the protest of the fishermen, recognizing that it was necessary because these fish are disappearing from the waters of our State.

PROF. DYCHE: If the fishermen get such a high price for the eggs it will be but a short time until you will have no fish. The lake sturgeon were caught for their eggs and in a short time they were exterminated. You will have to have some restrictions regarding the management of that business.

MR. ALEXANDER: We protect them six months out of the year, and permit no fish to be taken under twelve inches in length.

PROF. DYCHE: That is taking a long chance on saving them. You might protect them nine or ten months, but if you allow them to be caught at the spawning time the same result will follow.

PRESIDENT WARD: Professor Dyche is quite right in emphasizing the danger in collecting fish for caviar. They must be taken at the time when the eggs are nearly if not fully ripe and the consequent destruction is, of course, enormous. This might be met by providing protective measures through hatching, or otherwise, but it certainly is dangerous ground that the fishermen are treading on when they capture ripe fish for the eggs exclusively, and it is a fact that sturgeon have been exterminated in certain regions of the earth by reason of their pursuit for the eggs.

THE PROPERTIES AND UTILIZATION OF SOME MARINE ANIMAL OILS[1] [2]

By Dr. George F. White, *Clark College, Worcester, Mass.*

(From the Laboratories of the U. S. Bureau of Fisheries, Woods Hole, Mass., and Clark University Worcester, Mass.)

The term "fat" may be considered, for technical purposes, to include all those substances which are glycerides of fatty acids, exclusive of the lipoids, which may be nitrogenous and phosphorized glycerides such as lecithin. Fats are divided for convenience into solid and liquid fats, the latter being classified ordinarily as oils. It should be noted, however, that oils may become solid fats by lowering the temperature and solidifying the contained glycerides, so that the distinction is purely arbitrary. Oils, in turn, are either vegetable or animal, and to this class belong the marine animal oils.

Fish, liver and blubber oils constitute the class of marine animal oils and show fairly distinct differences in composition and behavior. Sperm oil is not included in these as it contains a large amount of spermaceti, which is a wax and not a fat, waxes being esters of other alcohols than glycerol. Some important and characteristic differences between a vegetable oil (linseed) and marine animal oils of various kinds, and of sperm oil and spermaceti, may be best shown by the following table, compiled from the results of experiments at Woods Hole.

It is not in the scope of this paper to discuss methods of preparing oils. The methods of obtaining menhaden oil are simple in principle, involving a digesting process, pressing by one means or another, steaming out the oil

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[1]Published by permission of Dr. Hugh M. Smith, U. S. Commissioner of Fisheries, Washington, D. C.

[2]For a fuller account of the industrial side of this topic, see "Aquatic Products in Arts and Industries," C. H. Stevenson, Part XXVIII, Report of the Commissioner, U. S. Commission of Fish and Fisheries, p. 177, 1902.

TABLE I.

CHARACTERISTIC PHYSICAL AND CHEMICAL CONSTANTS OF SOME VEGETABLE AND MARINE ANIMAL OILS.

Kind of Oil	Specific gravity at 30°c.	Viscosity at 50°c.	Iodine number	Saponification number	Acid number
Linseed	0.9251	0.1751	152.4	194.7	4.00
Menhaden	0.9230	0.1727	143.3	191.1	0.88
Dogfish (*Mustelus canis*)	0.9185	0.2135	135.9	193.0	0.94
Squeteague	0.9177	0.2402	103.9	196.5	7.40
Scup	0.9168	0.2141	117.3	188.9	16.73
Butterfish	0.9090	0.2092	91.1	191.4	62.07
Eel	0.9135	0.2026	117.4	191.1	1.02
Dogfish liver (*Mustelus canis*)	0.9164	0.1977	124.8	189.9	1.60
Dogfish liver (*Squalus acanthias*)	0.9187	0.2049	142.7	171.4	4.84
Dusky Shark liver	0.9127	0.2386	118.2	185.2	0.81
Sand Shark liver	0.9262	0.1943	....	182.7	1.52
Hammer-head Shark liver	0.9245	0.2682	155.5	174.1	3.32
Torpedo liver	0.9044	0.2133	111.0	164.0	0.92
Cod liver	0.9277	0.2001	142.6	185.8	1.82
Barn-door Skate liver	0.9253	0.1970	155.8	184.9	0.38
Sea-elephant	0.9135	0.2452	127.8	197.8	1.66
Sea-leopard	0.9153	0.1858	121.6	197.5	0.00
Whale	0.9192	0.1822	156.6	192.8	6.70
Blackfish head	0.9135	0.1132	33.90	277.8	0.81
Porpoise body	0.9221	0.1208	30.26	....	1.53
Porpoise jaw	0.9176	0.1084	30.68	286.0	0.89
Sperm	.....	0.1720	85.5	167.0	0.33
Spermaceti	0.8627	0.1040	65.75	137.7	0.26

from the filtrate, and reclaiming some oil of inferior grade by filter-pressing the gurry. Liver oils of good quality are obtained by steaming fresh livers for a short time and allowing the oil to rise. Extraction with solvents may be resorted to where difficulties are encountered, as in reclaiming oil from digested dogfish, the mushy character of which causes a poor separation in the modern screw-presses. I have obtained good fish and liver oils by steaming at brief intervals of time in an autoclave at 5 to 10 pounds pressure. This process suggests possibilities for the reclaiming of oil from dogfish.

Crude marine animal oils all have a fishy taste and odor. They turn dark on long standing, and may deposit a solid fat, which fat is composed of glycerides mainly

of palmitic, together with some stearic and oleic acids. This deposition of fat (roughly called "stearine" in the trade, and used for soap-making) is of course markedly hastened by cooling. It has been noted by the writer that the liver oil of the smooth dogfish deposits much larger amounts of "stearine" than does that of the spiny dogfish. Torpedo liver oil gave none even after one hour's standing over ice.

The specific gravities of the various marine animal oils and of linseed oil are very similar, averaging about 0.92 at 30° C.

The viscosity, which is of great importance in considering the value of oils for paints and lubricants, varies around the value 0.2 at 50° C. Viscosity values are expressed in C. G. S. units. I have studied this phase of the subject to a considerable extent and have devised a viscometer requiring only five minutes for a determination and but five cubic centimeters for a sample of oil. The accuracy of the instrument, method of manipulation, and results are discussed in the original papers.[1] It was found that the viscosity of the oils is very characteristic and constant even if the different samples of oils were obtained under diverse conditions. Mixtures of oils were studied, and it was observed that the *fluidities* (fluidity being the reciprocal of viscosity) of the mixtures are strictly additive; that is, from the fluidity the percentage composition of the mixture can be calculated. It was stated that such a test of the character of an oil is not of great value if taken by itself, but is well worth consideration along with other physical and chemical tests. The fluidities of fish and vegetable oil mixtures were also shown to be additive.

Some marine animal oils have the property of drying to a considerable degree, and this is a good reason for the assumption that such oils contain large amounts of unsaturated fatty acid esters. The nature of these is not well understood as it is extremely difficult to isolate such

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[1]Journal of Industrial and Engineering Chemistry, vol. 4, pp. 106 and 267 (1912).

unstable compounds without breaking them up. Ordinary distillation decomposes the oils, changes their composition, and the almost hopeless mixture of glycerides presents a very complex problem to the analytical chemist. The drying power of the oils is shown by the iodine numbers. The iodine number is the percentage of iodine absorbed by an oil, and is probably the constant which tells more of the value of the oil than any other. While many of the fish oils have iodine numbers nearly as great as that of linseed oil, they do not necessarily dry in exactly the same manner, a sticky gum being sometimes obtained instead of a hard, dry film.

Many attempts have been made to refine fish oils and rid them of their fishy odor, taste and color. Very few of these attempts have met with any degree of success. Physical methods may include washing with water and drying either by allowing to settle, or drying with calcium chloride, cooling to separate "stearine," allowing to stand over or filtering through fullers' earth, infusorial earth, or animal charcoal, and steaming under ordinary, reduced, or increased pressure. As far as my observations go, the use of such agents as charcoal do not change the character of the oils to any appreciable extent, especially if they are of fairly good quality to start. The results of steaming oils will be considered later.

Chemical methods of purification may be used, although very few of these attempts have met with any degree of success. The oil may be treated with a small amount of concentrated sulphuric acid and the slightly charred product allowed to settle, the albuminous impurities thus being dragged down. I have found this process practically worthless for marine animal oils. Treatment with ozonized air, and chlorine generated in various ways, have been tried, as well as very many other processes. That process which seems at present to promise ultimate success is the so-called hardening of the oils by hydrogen.

"The treatment of unsaturated oily bodies with hydrogen to obtain saturated derivatives is of great scientific and technical interest. In the fat industry a most fas-

cinating problem has been that of the conversion of oleic acid or olein into stearic acid or the corresponding glyceride."[1] Since fish oils contain large amounts of glycerides of unsaturated acids, under proper conditions they should add hydrogen directly, just as they take up bromine and iodine. Hydrogen is very active in the presence of finely divided nickel heated to a suitable temperature, and such carefully prepared nickel will hasten the reduction of any reducible substance.

Catalyzers are those substances which change the rate of a chemical reaction without being noticeably affected at the end of the reaction. "With a powerful catalyzer the hydrogenation of oils becomes a rapid, simple procedure; almost, as it sometimes seems, independent of the hydrogenating apparatus."

"Catalyzers recognized as useful for the purpose are nickel and palladium, although platinum, copper, iron and other metals have been used to a great extent. . . . As nickel is probably the most important of these catalyzers, in view of its efficiency and relatively low cost, it will be first considered. The preparation of an effective nickel catalyzer requires considerable care. The oxide or hydrate of nickel is first obtained by reduction of nickel nitrate, or precipitation of nickel hydrate from, say, a nickel sulphate solution by the addition of an alkali. Obtained in this or any other suitable manner, the next step is the reduction to metallic nickel. For this purpose the nickel is placed in a receptacle which may be heated controllably, and hydrogen gas is passed over the mass at a temperature ranging from 250° to 500° C. or so, until water is no longer evolved." Such a catalyzer is very sensitive to outside influences, and is poisoned by certain gases, loses its activity if exposed to the air, etc. "Catalyzer made from the oxide without supporting material, weight for weight, is hardly as efficient as when the active surface is increased by the use of a carrier. Hence we find many proposals for the production of cata-

[1]The quotations referring to the hydrogenation of oils are taken from the article of C. Ellis, Journal of Industrial and Engineering Chemistry, Vol. 5, p. 95 (1913).

lyzers with a great diversity of carriers, ranging from pumice stone and kieselguhr to charcoal and sawdust."

"By hydrogenation, oils which formerly made soaps only of soft consistency, now yield the more valuable hard soaps. This has led to a very rapid development of the art with respect to the production of soap-making fats. In particular, fish and whale oils have been made use of because these oils may be completely deodorized by the addition of hydrogen. . . . When hydrogenated down to an iodine number of about 50, fish oil has the consistency of hard tallow and the odor of fish oil is wholly absent. Even the fishy taste is scarcely in evidence. For soap-making, this product is satisfactory as it complies with the test for a deodorized fish oil suitable for soap-making in that the odor of the original oil is not apparent when ironing laundered goods on which such soaps are used."

In the consideration of the edibility of hydrogenated oils, the presence of the catalyzer in the finished product must be considered. "Whale oil, containing 0.6 per cent. fatty acid, yielded 0.006 per cent. ash and 0.0045 per cent. nickel oxide. Such an amount of nickel presumably would not be tolerated in a product intended for edible purposes."

MENHADEN OIL.

In the United States, menhaden oil obtained in the south Atlantic waters is called "Southern" oil and is distinguished from "Northern" oil by its lighter color, and by the fact that it contains more glycerides of higher fatty acids, therefore depositing a greater quantity of stearine when cooled. The oil is sold under several trade names—"Prime Crude," "Brown Strained," "Light Strained," "White Bleached" and "Yellow Bleached," depending on the degree of refinement. Sometimes the grades are called "A," "B," "C," and "D," the distinction being based on the color, "A" grade being a very light yellow, while "D" grade is the very dark brown oil.

The condition of the market in December, 1913, may be best shown by the following quotation:[1] "Authorities estimate this season's yield of oil will come fully 40 per cent. short of last year's output. Crude Southern oil was offered at 33 cents per gallon, f. o. b. Baltimore, but there were no buyers at this price. Northern oil was nominal at 36 to 37 cents per gallon, most sellers asking the outside figure. The pressed grades were steady in the face of a quiet demand. There was a moderate inquiry for the light pressed. Prices closed unchanged as follows: light and brown strained, 40 to 42 cents; yellow bleached, 42 to 44 cents; white bleached, 44 to 45 cents per gallon."

Menhaden oil is used in the leather industry for currying, in soap-making, and in the paint and varnish industry as a substitute for linseed oil. Its use for rubber substitutes, etc., is kept a trade secret.

"The oil that gives the best and most lasting results for paint purposes is menhaden oil, and the winter bleached variety is the one that should be recommended.[2] This is an oil fairly pale in color, with an iodine number of 150 or over, and with little or no fishy odor. . . . The results I have obtained from the proper grades of fish oil . . . warrant me in saying that fish oil in the hands of an intelligent manufacturer, and used up to 75 per cent., produces excellent results for exterior purposes. For interior purposes fish oil does not seem to be desirable, for it gives off noxious gases for a long time."

"Menhaden oil should, of course, be used with a drier, and for that purpose the best results are obtained by means of a Tungate drier. Tungate drier is one in which tung oil or China wood oil is boiled with a lead and manganese dioxide, and when the solution is complete, this is then mixed with a properly made resinate of lead and manganese. Such a drier becomes soluble in the oil at temperatures over 100° C., and hardens the resulting

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[1]Oil, Paint and Drug Reporter, Vol. 84, p. 35, Dec. 15, 1913.

[2]Toch. "Fish Oil as a Paint Vehicle." Journal of Industrial and Engineering Chemistry. Vol. 3. p. 627. (1911).

paint very thoroughly. For fabrics, however, fish oil must be heated to a temperature of over 200° C., and if air is injected at such a temperature the glycerides are expelled and thick oil is produced which, in conjunction with the drier just named, is equally good for printing inks. It is advisable, however, to add at least 25 per cent. of either a heavy bodied linseed oil or a raw linseed oil which does not break before the manipulation just referred to has begun."

"Since last year some of the enamel leather and printing ink manufacturers have adopted the use of fish oil as a medium to replace linseed oil, with excellent results, and the enamel leather which is produced, while not so high in gloss as that made entirely of linseed oil, is much more flexible and possesses an unctuousness which prevents it from cracking. But fish oil for leather purposes shows a peculiar defect, and a campaign of education will be necessary if ever this material is to be used for the manufacture of shoes or auto tops, for fish oil, particularly when it originally has a high acid number, seems to effloresce and gives an undesirable bloom to enamel leather, which, however, can be removed from the surface by the ordinary application of benzine or a mixture of benzine and turpentine."

"We are all aware that paint made from fish oil can be applied to hot surfaces and will not blister or peel as readily as that made from linseed oil, and for this purpose—as a smoke-stack paint—it is very desirable."

"There is great demand for baking japans which shall be flexible and at the same time so thoroughly baked that they adhere to the surface most tenaciously and form an excellent enamel, and for this purpose we know that the reasonable use of fish oil improves baking japans very much indeed. We are also aware that along the seacoast, where paint disintegrates very rapidly on account of the sea air, a fairly liberal use of properly treated fish oil serves a useful purpose."

"When red lead is mixed 33 pounds to a gallon of linseed oil it thickens up after a short time and becomes

unfit for use. A properly neutralized fish oil prevents the hardening or setting of the red lead in the package, and a paste of this material can be transported a great distance and will last many months in a fresh and soft condition."

COD LIVER OIL.

The production of a medicinal cod liver oil of good quality requires considerable care. Such oil is now made from selected fresh livers, those livers being discarded which are at all discolored. The livers are subjected to the action of steam at a fairly low temperature, (the best oil is obtained when the temperature is not allowed to exceed 70° C.) and the oil rising to the top is skimmed off. This oil is of the first grade, and after filtering from liver tissue, may be bleached by treatment with fullers' earth or by exposure to the sun. Longer heating affords a darker oil, and a brown oil may be finally obtained by pressing the residues.

Good medicinal oil should be of very light color, slight fishy odor and taste. It should have a small amount of free fatty acids, of volatile acids, and its iodine absorption value should be high. Its medicinal value is very probably not due to the amount of free acids, to the small amount of iodine contained in all cod liver oil, nor to the presence of any bases from the decomposed protein matter of the liver. Lewkowitsch[1] thinks that "the medicinal effect of cod liver oil . . . must be looked for in the facility with which it is hydrolyzed or digested, and it cannot be doubted that this property is caused by the peculiar constitution of its unsaturated fatty acids. From the medicinal point of view, that cod liver oil is the best which has been prepared from fresh livers and kept protected from the action of light and air."

There is on the market an oil called "cod oil" which is nothing but a crude cod liver oil. It is prepared in

[1] "Chemical Technology and analysis of Oil, Fats and Waxes." Vol. II, p. 361.

this country on the Eastern and Western coasts. Livers of other fish than the cod help to increase the supply of this oil. Cod oil, on cooling, deposits "stearine" which may be used for soap-making, while the expressed oil is employed in the leather industry. In December, 1913, domestic cod oil was selling for 37 cents a gallon.

TORPEDO LIVER OIL.

The liver of the torpedo yields a large amount of oil; one liver weighing 15 pounds gave one gallon of oil. The unrefined oil obtained by steaming the livers is a very light yellow oil, of slight fishy taste and odor, and deposits no stearine when cooled. Treatment of the oil with bleaching powder seemed to improve the quality only slightly, the physical and chemical properties remaining practically unchanged. An exceedingly clear, light colored and odorless product was obtained when the crude oil was subjected to the action of steam. The oil was heated by steam, a current of steam was passed through, and drawn out under reduced pressure. Thus all volatile aldehydes (the odor of acrolein was decidedly noticeable in preparing the crude oil from the livers), free fatty acids of low boiling point, and all those products causing the fishy odor, were removed.

The oil was hydrogenated at a temperature of 200° C. in the presence of reduced nickel. Hydrogen was simply bubbled through the oil which was placed in a vessel

TABLE II.

PROPERTIES OF CRUDE AND REFINED TORPEDO LIVER OIL.

	Acid number	Saponification number	Iodine number	Viscosity at 50°c.	Density at 30°c.
Crude oil	0.70	165.4	110.2	0.2097	0.9013
Oil treated with bleaching powder	0.73	....	104.0	0.2156	.....
Oil treated with steam	...	....	104.6	0.2142	0.9049
Oil treated with hydrogen	0.91	....	97.2	0.2629	0.9066

heated by an oil bath. The nickel was deposited on asbestos fibre. An oil of pleasant nutty odor was prepared by hydrogenating for a few hours. It is hoped that this problem may be studied to a greater extent.

While torpedo liver oil has been used to a small extent by some fishermen for rheumatism, it has otherwise been unutilized. It was applied to the bearings on lathes, to the valve-stem of the steam engine, and elsewhere in the machine shop at Woods Hole. The results were very promising. It of course saponified readily on the steam engine, and was found an excellent lubricant as it did not gum, although the bearings on the lathe heated up somewhat. It is too light an oil for such purposes, as the viscosity is low, but it should serve well as a spindle oil. The refined oil should be an excellent lubricant for light machinery.

SPINY DOGFISH LIVER OIL.

Spiny dogfish livers yield 45 to 55 per cent. oil of good quality if rendered properly. Prepared in the best manner, the oil is light yellow in color, clear, and of slight odor. Bleaching powder does not improve the oil to any extent, nor treatment with charcoal or diatomacious earth. By the steam treatment as with the torpedo liver oil, a product of excellent character was obtained. The following table presents the results of analyses:

TABLE III.

PROPERTIES OF CRUDE AND REFINED SPINY DOGFISH LIVER OIL.

	Acid number	Saponification number	Iodine number	Viscosity at 50°c.	Density at 20°c.
Crude oil	0.59	172.0	116.1	0.2171	0.9066
Oil treated with bleaching powder	0.62	171.4	....	0.2186	.....
Oil treated with steam	0.59	172.6	112.7	0.2183	0.9083

While the character of the oil of the torpedo liver varies but little, as evidenced by the two sets of constants

given in Tables I and II, that of the spiny dogfish shows considerable variation, especially in the iodine number. Thus Thomson and Dunlop[1] obtained an iodine value of 126.4, and 8.4 per cent. unsaponifiable matter. I found the iodine value to be 116.1 in one case and 142.7 in another, and 2.65 per cent. unsaponifiable matter. The oil should be studied further to characterize it fully, particularly with regard to the volatile and soluble acids.

Lewkowitsch[2] states that the dogfish "is caught on the coast of Oregon, Washington and British Columbia in large quantities. One hundred livers are stated to yield 6 to 8 gallons of oil. The oil is not generally kept separate from cod liver oil, and is sold in admixture with the latter for currying purposes." Dogfish liver oil carefully prepared may well be used for other than the above purpose.

SPINY DOGFISH BODY OIL.

The oil in the body of the dogfish is retained exceedingly tenaciously, and steaming under pressure does not seem to be wholly satisfactory. Pressing in the continuous screw presses yields a soft mushy product from which it is difficult to obtain a good yield of oil. Extraction by solvents is being tried at some plants now in operation for the manufacture of fertilizer and oil.

By extraction of the dry flesh with ether I obtained a brown oil with the following constants:—iodine number, 128.3; saponification number, 182.4; acid number, 1.66; density at 30° C., 0.9176; viscosity at 50° C., 0.1766. The oil is of lower quality than the liver oil, although its drying power is fully as great as indicated by the iodine absorption value.

SPINY DOGFISH EGG OIL.

The utilization of dogfish eggs for the tanning of leather is dependent on the quality of the contained oil.

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[1]Chemical Technology of Oils, etc. Vol. II, p. 370.
[2]Ibid. p. 368.

I found that in one sample of eggs there was 44.79 per cent. water, and 22.37 per cent. oil as obtained by extraction with carbon tetrachloride. This makes 49.96 per cent. oil in the dry yolk.

By extracting the dry yolks with ether, a rather viscous, light brown oil was obtained, of slightly fishy odor. This oil contained a solid fat which possibly consisted largely of "stearine," but probably was also composed of "lecithin," a nitrogenous and phosphorized glyceride which is found in egg yolk to a considerable extent. A more intensive study of this oil will be made.

The constants of the oil are as follows:—iodine number, 124.1; saponification number, 176.0, acid number, 8.1; density at 30°, 0.9268; viscosity at 50°, 0.3610.

* * *

The other shark oils are of not enough commercial importance on account of the supply, and the qualities of the blubber oils mentioned in Table I are too well known, to be considered here. From the interest in the skate on account of its value for fertilizer and glue, the exceptionally high iodine value of the liver oil should be noted (this value is exceeded sometimes) and its possible use as a drying oil should be considered.